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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04L — A2

(11) International Publication Number: **WO 99/14882**

(43) International Publication Date: 25 March 1999 (25.03.99)

(21) International Application Number: PCT/US98/19636

(22) International Filing Date: 18 September 1998 (18.09.98)

(30) Priority Data:
08/933,388 19 September 1997 (19.09.97) US

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(81) Designated States: CA, CN, JP, KR, MX, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: A PACKET-BASED TELEMEDICINE SYSTEM FOR COMMUNICATING INFORMATION BETWEEN CENTRAL MONITORING STATIONS AND REMOTE PATIENT MONITORING STATIONS

(57) **Abstract**

The present invention provides a packet-based telemedicine system for communicating video, voice and medical data between a central monitoring station and a patient monitoring station which is remotely-located with respect to the central monitoring station. The patient monitoring station obtains digital video, voice and medical measurement data from a patient and encapsulates the data in packets and sends the packets over a network to the central monitoring station. Since the information is encapsulated in packets, the information can be sent over multiple types or combinations of network architectures, including a Community access Television (CATV) network, the Public Switched Telephone Network (PSTN), the Integrated Services Digital Network (ISDN), the Internet, a local area network (LAN), a wide area network (WAN), over a wireless communications network, or over an asynchronous transfer mode (ATM) network. Thus, a separate transmission protocol is not required for each different type of transmission media. Rather, a single transport/network layer protocol is used for encapsulating the information in packets at the sending end and for de-encapsulating the information at the receiving end. Furthermore, by sending the information in packets, the video, voice and measurement data can be integrated and sent over a single network.

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A PACKET-BASED TELEMEDICINE SYSTEM FOR COMMUNICATING INFORMATION BETWEEN CENTRAL MONITORING STATIONS AND REMOTE PATIENT MONITORING STATIONS

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to and the benefit of the filing date of copending provisional application entitled **AN ELECTRONIC HOUSE CALL SYSTEM**, assigned Serial No. 60/026,986, filed September 20, 1996 (Attorney Docket Number 62002-8450), which is hereby incorporated herein by reference.

TECHNICAL FIELD OF THE INVENTION

This invention generally relates to the field of telemedicine and, more particularly, to a telemedicine system which communicates information between central monitoring stations and remotely-located patient monitoring stations by encapsulating the data in packets which can be sent over multiple types or combinations of network architectures.

BACKGROUND OF THE INVENTION

Generally, telemedicine is a term used to describe a type of patient care which involves monitoring of a patient's condition by a healthcare worker located at a healthcare facility which is remote with respect to the location of the patient. Telemedicine, if adequately employed, is capable of providing enormous benefits to society. One such benefit is that patients can be examined without having to travel to a healthcare facility. This feature is particularly important for patients who live in remote areas who may not be able to easily travel to the nearest healthcare facility, or who need to be examined by a healthcare worker located far away from the patient, in another state, for example.

Another benefit of telemedicine is that it is capable of allowing a patient to be examined more often than would be possible if the patient were required to travel to a healthcare facility due to the ease with which it can be administered. For example, if a patient's condition requires that measurements be taken several times a day, it would be impractical for the patient to travel to and from a healthcare facility each time a measurement needs to be taken. It probably would be necessary

for the patient to be admitted to the healthcare facility. The use of telemedicine could allow these measurements to be taken at the patient's home while the healthcare worker observed the patient or the measurement data from the healthcare facility.

Another benefit of telemedicine is that it allows a patient to be examined in a more timely manner than if the patient was required to travel to the healthcare facility. This is important in urgent situations, such as when a patient's condition becomes critical and emergency procedures must be taken immediately.

Many various types of telemedicine systems are known. One example of such a system is disclosed in *David et al.*, U.S. Patent No. 5,441,047, issued August 15, 1995, which discloses an ambulatory patient health monitoring system for monitoring a remotely-located healthcare patient from a central station. The system includes instruments at the remote location for measuring the medical condition of the patient. The medical condition may correspond to health parameters, such as heart rate, respiratory rate, pulse oximetry and blood pressure. The system includes a first audio-visual camera disposed at the patient location and a second audio-visual camera disposed at the central station. Audio and video information is transmitted between the patient's remote location and the central station via a communications network, such as an interactive cable television network. Patient data is transmitted between the patient remote location and the central station by a separate communications network, such as satellite, radio transmission or telephone lines. A display is located at the patient's remote location and at the central station to allow the patient and the healthcare worker to observe each other simultaneously.

One of the disadvantages of the system disclosed in the *David et al.* patent is that, although it refers to sending the information between the healthcare worker and the patient via various types of networks, the information sent from the patient's home will have to be formatted in accordance with a different communications protocol for each of these different networks. Therefore, although the *David et al.* patent refers to the capability of using different types of networks, the system disclosed in the *David et al.* patent is not "network-independent" because the data must be formatted in accordance with a particular protocol at the sending end and the formatting process

will have to be reversed at the receiving end in a different manner for each type of network. At the very least, this will require different software and/or hardware at each end for each different transmission media used. Another disadvantage of the system disclosed in the *David et al.* patent is that the audio and video data are sent over one communications network and the patient data is sent over another communications network.

Another example of a telemedicine system is disclosed in *Tamura*, U.S. Patent No. 5,434,611, issued July 18, 1995. This patent discloses a telemedicine system having a two-way CATV network for transmitting images, voice and data between equipment located at the patient's home and equipment located at a medical office. Cameras are located in both the patient's home and in the medical office to provide return images between the doctor and the patient. In order for the doctor's terminal to communicate with the patient's terminal, the doctor's terminal sends a signal over a control line to the patient's terminal. A line controller then selects a communication channel for the session by selecting an unused channel in a multiple channel access (MCA) system. The terminals then automatically tune to the assigned communications channel and the information is communicated over the assigned channel between the patient and the doctor.

One disadvantage of the system disclosed in the *Tamura* patent is that any communication between the doctor and patient must be set up by sending a signal which the line controller detects. The line controller then selects an unused channel for the communication. It also appears that the signal must be initiated by the doctor because the text of the patent only describes the situation where the doctor sends the signal to initiate the session. In any event, the system requires that a direct connection be made between the patient's terminal and the doctor's terminal. No provision is made for allowing medical measurement data to be sent to the doctor's terminal without a direct connection being made between the patient's terminal and the doctor's terminal. Therefore, in accordance with the system disclosed in the *Tamura* patent, it would be impossible for information relating to the patient's condition to be sent by the patient's terminal to the doctor's terminal in the absence of

a direct connection being made between the terminals, which requires that the doctor be present for the session.

It would be advantageous to provide a telemedicine system which would allow either a patient or a healthcare worker to initiate a diagnostic session to cause diagnostic measurements to be taken and sent to a location, such as a healthcare facility, where medical files could be automatically updated by the data. One advantage of such a system is that a healthcare worker would not have to administer a diagnostic session and, therefore, would not have to participate in the session. Another advantage of such a system is that medical files could be automatically updated without any action on the part of a healthcare worker being required. Furthermore, as the medical files are automatically updated, the patient's condition could be automatically monitored so that, in the event that the patient's condition falls below a predetermined level, remedial measures can be taken. It would also be advantageous to provide a telemedicine system which would allow video, voice and medical data to be integrated and sent over a single network.

Accordingly, a need exists for a telemedicine system which is network-independent and which is capable of allowing video, voice and data relating to the patient's condition to be integrated and sent from a remotely-located patient terminal to a healthcare facility without the necessity of a direct connection being set up between the patient and the healthcare worker.

SUMMARY OF THE INVENTION

The present invention provides a packet-based telemedicine system for communicating video, voice and medical data between a central monitoring station and a patient monitoring station which is remotely-located with respect to the central monitoring station. The patient monitoring station obtains digital video, voice and medical measurement data from a patient and encapsulates the data in packets and sends the packets over a network to the central monitoring station. Since the information is encapsulated in packets, the information can be sent over multiple types or combinations of network architectures, including a Community Access Television (CATV) network, the Public Switched Telephone Network

(PSTN), the Integrated Services Digital Network (ISDN), the Internet, a local area network (LAN), a wide are network (WAN), over a wireless communications network, or over an asynchronous transfer mode (ATM) network. Thus, a separate transmission protocol is not required for each different type of transmission media. Rather, a single transport layer protocol is used for encapsulating the information in packets at the sending end and for de-encapsulating the information at the receiving end. Furthermore, by sending the information in packets, the video, voice and measurement data can be integrated and sent over a single network.

When the information has been de-encapsulated at the central monitoring station, the information is processed and analyzed by software and/or hardware to determine which patient caused the information to be sent, the type of diagnostic measurement comprised in the information, and the diagnostic measurement represented by the information.

The patient monitoring station of the telemedicine system of the present invention comprises a plurality of medical devices which are connected to a control unit via a medical device interface which controls the transmission of data from the medical devices to the control unit. The patient monitoring station is configured so that the control unit and the medical devices can communicate with each other through the medical device interface. The medical device interface preferably uses a single interrupt to request data transfer to the control unit. When the control unit has data to send to one of the medical instruments, it transmits the data to the medical device interface along with the address of the medical device that is to receive the data. The medical device interface then decodes the address and transmits the data to the proper medical device.

When a medical device has data to send to the control unit, it transmits the data to the medical device interface. The medical device interface then sends an interrupt request to the control unit. The control unit processes the interrupt request and the data is transmitted from the medical device interface to the control unit. The control unit then formats the data and outputs it to a communications device, preferably a LAN card, which encapsulates the data in accordance with the

transport layer protocol and outputs it onto the network to be sent to the central monitoring station.

The control unit of the patient monitoring station also comprises a videoconferencing interface device which formats voice and video data received by the videoconferencing interface device from a camera and microphone located at the patient monitoring station. The control unit then delivers the formatted video and voice data to the communications device which encapsulates the data in accordance with the communications protocol and outputs it onto the network to be sent to the central monitoring station.

The central monitoring station also comprises a control unit which preferably is identical to the control unit of the patient monitoring station. The control unit of the central monitoring station communicates with a videoconferencing interface device of the central monitoring station which formats voice and video data received by the videoconferencing interface device from a camera and microphone located at the central monitoring station. The control unit then delivers the formatted video and voice data to a communications device, preferably a LAN card, which encapsulates the video and voice data in accordance with the transport layer protocol and outputs it onto the network to be sent to the patient monitoring station.

When the control unit of the patient monitoring station receives packets of data sent to it from the central monitoring station, the communications device of the patient monitoring station de-encapsulates the packets of information and determines whether the information is to be sent via the medical device interface to one of the medical devices or whether the information is to be sent to a display screen and speaker via the videoconferencing interface device. Once this determination is made, the information is sent to the appropriate interface device.

When the control unit of the central monitoring station receives packets of data sent to it from the patient monitoring station, the communications device of the central monitoring station de-encapsulates the packets of information and determines whether the information is diagnostic data from one of the medical devices or whether the information is videoconferencing information. If the information is

videoconferencing information, the information is sent to the videoconferencing interface device. The videoconferencing interface device decodes the information and outputs it to a display screen and speaker located at the central monitoring station. If the information is diagnostic data, the control unit interprets the data. Once the diagnostic data has been interpreted, the control unit may further process the data and/or save it in a storage device.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of the telemedicine system of the present invention comprising a plurality of patient monitoring stations and a plurality of central monitoring stations.

Fig. 2 is a block diagram of one of the patient monitoring stations shown in Fig. 1 comprising N medical devices connected via a device interface to a control unit.

Fig. 3 is a flow chart demonstrating the processing of data received by the control unit shown in Fig. 2 from one of the central monitoring stations shown in Fig. 1.

Fig. 4 is a flow chart demonstrating the transmission of data from one of the medical devices shown in Fig. 2 to the control unit shown in Fig. 2 and then to the central monitoring station shown in Fig. 1.

Fig. 5 is a flow chart demonstrating the processing and packeting of video and audio data at the patient monitoring station control unit shown in Fig. 2 before the packets are sent to the central monitoring station shown in Fig. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 illustrates the telemedicine system 10 of the present invention comprising a plurality of central monitoring stations 11 which are in communication via a network 16 with a plurality of patient monitoring stations 18. As illustrated, a central monitoring station 11 may be provided at, for example, the doctor's home 12, the doctor's office 13, or at a hospital 14, each of which are in communication with network 16. In accordance with the present invention, data of various types is

sent to and from one or more of the central monitoring stations 11 to and from one or more of the patient monitoring stations 18 in the form of digital packets, as discussed in more detail below with respect to Figs. 2-5. It should be noted that the patient monitoring stations 18 and the central monitoring stations 11 may be located at any location capable of having access to communication network 16. It should also be noted that a plurality of patient monitoring stations 18 can communicate with a single central monitoring station 11 and that a plurality of central monitoring stations 11 can communicate with a single patient monitoring station 18.

Network 16 can be multiple types or combinations of network architectures, including the PSTN, ISDN, a cellular or wireless network, a LAN, a WAN, a Community Access Television network (CATV), the Internet, an ATM network, or a combination of one or more of these networks. All of the information transmitted between a patient monitoring station 18 and a central monitoring station 11 is encapsulated in packets using a preselected communications protocol. In accordance with the preferred embodiment of the present invention, TCP/IP is used as the transport layer/network layer protocol for encapsulating the data in packets. However, it will be apparent to those skilled in the art that other types of communications protocols are suitable for use with the present invention. TCP/IP is preferred due to its wide acceptance and use.

Fig. 2 is a block diagram demonstrating one of the patient monitoring stations 18 shown in Fig. 1. Each patient monitoring station 18 comprises a control unit 22, an address/data bus 27, a videoconferencing interface device 26, videoconferencing equipment 23, a medical device interface 24, and one or more medical devices 28-30. In accordance with the preferred embodiment of the present invention, medical device interface 24 comprises a serial card that has multiple serial ports and uses only one interrupt line (not shown) to communicate with control unit 22. The medical device interface 24 is connected to a plurality of medical devices 28-30 and to the control unit 22 via address/data bus 27. The control unit 22 comprises telemedicine application software 25 which controls the flow of data to and from the medical devices 28-30 via the medical device interface 24.

Videoconferencing interface device 26 comprises hardware and/or software which controls the processing of data received by the control unit 22 from the videoconferencing equipment 23 to convert the data into a form which is suitable for transmission over network 16. The videoconferencing interface device 26 is also responsible for processing videoconferencing data received from the central monitoring station to convert the data into a form which is suitable for display on a display screen comprised by videoconferencing equipment 23.

When data is to be sent from the control unit 22 to one of the medical devices 28-30, the control unit 22 sends data to medical device interface 24 via address/data bus 27. Medical device interface 24 then transmits the data to the appropriate medical device 28-30 by decoding the address information placed on the address/data bus 27. When data is to be sent to control unit 22 from one of the medical devices, the medical device transmits the data to medical device interface 24. Medical device interface 24 then buffers and queues the requests and then uses a single interrupt line to indicate that it has data to transmit to control unit 22. Once control unit 22 is prepared to receive the data, medical device interface 24 sends the data to control unit 22 via the address/data bus 27.

The medical devices 28-30 can include, but are not limited to, blood pressure devices, thermometers, pulse oximetry devices, electrocardiograms (EKGs), scales and stethoscopes. Additionally, medical devices can be freely interchanged with one another simply by unplugging one medical device from the interface and plugging in another. This "plug and play" compatibility, is made possible by the system configuration and use of a single interrupt interface and provides maximum flexibility in configuring the telemedicine system to meet particular needs. Numerous combinations of different medical devices can be used in one telemedicine system via the device interface. The device interface itself can be implemented in numerous ways, including but not limited to, an RS-232 interface, a single serial communications card, a bus such as the Firewire (IEEE 1394) or Universal Serial Bus (USB), or any other interface which uses a single interrupt in the data transfer process. The control unit can also be implemented in

numerous ways including, but not limited to, a personal computer or any other type of processing unit.

Figs. 3 and 4 generally portray the steps involved in a transfer of data between a medical device and control unit 22. With respect to Fig. 3, when the patient monitoring station 18 receives data from the central monitoring station 11, control unit 22 determines whether the data is directed to one of the medical devices 28-30, to the videoconferencing equipment 23, or to application-level data, as indicated by block 34. The received information is encapsulated in packets of digital data. The communications device (not shown) of the control unit 22 de-encapsulates the packets and the data is analyzed to determine whether the data is videoconferencing data, medical instrument command data, or application-level data, as indicated by block 35 and 36, respectively. If the data is directed to the videoconferencing equipment 23, the data is processed by the videoconferencing interface device 26 and output to videoconferencing equipment 23, as indicated by blocks 41 and 42, respectively. This data can be control commands and data for controlling the operation of the videoconferencing equipment 23 (e.g., controlling the pan or tilt of the camera), or it can be image and voice data captured by the videoconferencing apparatus located at the central monitoring station 11, as discussed in more detail below.

If it is determined at block 36 that the data is application-level data, the data is processed within the control unit 22 by the telemedicine application, as indicated by block 37. Application-level data may be, for example, a message to the patient, status information, etc.

If it is determined at block 36 that the received data is medical device command data, the medical device interface 24 decodes the address and enables the selected serial port corresponding to the requested medical device, as indicated by block 38. The selected serial port receives the data from the address/data bus 27, as indicated by block 39. The intended medical device then receives the data from medical device interface 24 over the selected serial port (not shown).

Fig. 4 is a block diagram illustrating the transfer of data from one of the medical devices 28-30 to the control unit 22. In accordance with the preferred

embodiment of the present invention, medical device interface 24 comprises a serial interface card with one serial port connected to each medical device 28-30. As before, the telemedicine application software 25 is running on control unit 22 during the transmission process. In step 43, one or more of the medical devices 28-30 sends data to medical device interface 24. The medical device interface 24 buffers and queues the data and then invokes an interrupt using the single interrupt line (not shown), as indicated by block 44. The control unit 22 then invokes an interrupt service routine to handle the interrupt request, as indicated by block 45. As stated above, numerous routines for processing the resulting data can be included in the telemedicine application software 25 for acquiring data from the various types of medical devices and for converting the data into a form suitable for transmission to the central monitoring station 11. It will be understood by those skilled in the art which types of routines will be needed and the manner in which those routines should be constructed to accomplish these tasks.

Once the interrupt service routine has been invoked, it processes the interrupt and notifies the telemedicine application software 25 of the availability of the data, as indicated by blocks 46 and 47. The telemedicine application software 25 then reads the data sent by the medical device, as indicated by block 48. The medical device data is then sent by the control unit 22 to the communications device, which preferably is a LAN card (not shown), which encapsulates the data in packets, as indicated by block 51. The packets are then output by the LAN card onto the network 16, as indicated by block 52.

The medical device interface 24 can include numerous serial ports to handle data sent by multiple medical devices 28-30. In essence, medical device interface 24 itself handles all data transfer, buffering, and priority functions associated with using a single interrupt. Therefore, since numerous combinations of medical devices 28-30 can be connected to device interface 24, device interface 24 in conjunction with the telemedicine application software 25 provides a "plug-and-play" type of compatibility between the control unit 22 and the medical devices 28-30. Therefore, medical devices 28-30 can be connected and disconnected from device interface 24 in any combination. This feature of the single interrupt

interface 24 and telemedicine application software 25 provides maximum flexibility in configuring the telemedicine system 10.

Additionally, the telemedicine application software 25 in conjunction with the interface 24 may perform any necessary conversion functions. The telemedicine application software 25 can include routines for converting data into a form comprehensible by one or more medical devices 28-30, by the control unit 22, or by medical device interface 24. This interpretation function facilitates communication among different devices and allows the effective use of the single interrupt device interface 24. However, it should be noted that although the single interrupt architecture of the present invention is preferred, it will be apparent to those skilled in the art that this is not necessary and that any means by which one or more medical devices 28-30 can transfer data to and from the medical devices 28-30 to and from the control unit 22 is suitable for use with the present invention.

The telemedicine application software 25 in conjunction with medical device interface 24 may also perform the function of allowing medical devices using different protocols to communicate. For example, the protocol used by a medical device 28-30 may be different from any other medical device. The telemedicine application software 25 can contain routines for allowing these different protocols to communicate via the common device interface 24.

Fig. 5 is a flow chart functionally illustrating the processing of videoconferencing data received by control unit 22 from videoconferencing equipment 23 via videoconferencing interface device 26. Videoconferencing equipment 23 includes a camera and microphone for obtaining video and audio images of the patient. The videoconferencing software comprised by the videoconferencing interface device 26 processes the video and audio input into a format suitable for the communications device to packet, as indicated by block 54. The data is then provided to the communications device, as indicated by block 55.

As stated above, preferably the communications protocol used with the present invention is TCP/IP. It will be understood by those skilled in the art the manner in which the data is formatted prior to being sent to the communications device to be packeted. Generally, the data is provided to the communications

device in a serial bit stream. The identity of the patient and the identity of the central monitoring station to which the data is to be sent is also provided to the communications device. In the case where diagnostic measurement data from one or more of the medical devices is being sent with the videoconferencing data, an indication of the type of measurement being sent and a representation of the measurement itself is also provided to the communications device. Optionally, other types of information may also be provided to the communications device, such as the date and time of the measurement, the type of medical device which took the measurement, and the location or identity of the patient monitoring station.

TCP/IP then parses the data into packets, each packet including a field indicating the destination to which the packet is being sent. The packets are then output by the communications device onto the network, as indicated by block 56. Therefore, at a minimum, the packets sent which correspond to a particular measurement will include an indication of the identity of the patient, the type of measurement being transmitted, and a representation of the measurement itself. The plurality of packet data fields define the identity of the patient, an indication of the type of measurement, and a representation of the measurement itself.

The central monitoring stations 11 are essentially the same as the patient monitoring station, with the exception that the central monitoring stations do not comprise a medical device interface or the medical devices. The processing of data at the central monitoring stations 11 is essentially the same as that depicted in Figs. 3 and 5 for the patient monitoring stations 18, with the exception that no data for controlling medical devices is received by the central monitoring stations 11. Also, the telemedicine software at the central monitoring stations 11 is different from the telemedicine software at the patient monitoring station. The telemedicine software at the central monitoring station includes one or more routines for analyzing measurement data to determine the type of measurement data received, e.g., whether the data is blood pressure data, temperature data, pulse oximetry data, etc. The telemedicine software at the central monitoring station also includes a functionality for determining the identity of the patient to whom the data corresponds. This can be accomplished by parsing the de-encapsulated data using

the order of the data in the de-encapsulated data stream and preselected indications contained in the data stream to determine the measurement type, the measurement itself, and the identity of the patient.

A medical file maintained for the patient at the central monitoring station may then be updated to reflect the received measurement. Alternatively, the medical files may be maintained at a server located outside of the central monitoring stations 11 which is capable of being accessed by the central monitoring stations and/or by the patient monitoring stations 18. It will be apparent to those skilled in the art the manner in which such an analysis is performed.

It will be apparent to those skilled in the art that many variations and modifications can be made to the present invention without departing from the spirit and scope of the present invention. All such variations and modifications are intended to be within the scope of the present invention, as set forth in the following claims.

What is claimed is:

1. A telemedicine system for transmitting voice, video and medical data between a central monitoring station and a patient monitoring station over a network, the telemedicine system comprising:

a first control unit located at the patient monitoring station, the control unit receiving medical data from one or more medical instruments in communication with the control unit and delivering the medical data to a first communication device in communication with the control unit, the communication device encapsulating the medical data in packets in accordance with a preselected communication protocol and outputting the packets onto the network; and

a second control unit located at the central monitoring station, the second control unit being in communication with a second communication device, the second communication device receiving the packets output by the first communication device onto the network, the second communication device de-encapsulating the packets to reconstruct the medical data, the reconstructed medical data being provided to the second control unit.

2. The telemedicine system of claim 1, wherein the telemedicine system is for transmitting voice, video and medical data between a plurality of central monitoring stations and a plurality of patient monitoring stations, each patient monitoring station comprising said first control unit and each of said central monitoring stations comprising said second control unit.

3. The telemedicine system of claim 1, wherein the network is a community access television (CATV) network.

4. The telemedicine system of claim 1, wherein the network is an asynchronous transfer mode (ATM) network.

5. The telemedicine system of claim 1, wherein the network is the Internet.

6. The telemedicine system of claim 1, wherein the network is a Public Swiched Telephone Network (PSTN).

7. The telemedicine system of claim 1, wherein the network is an Integrated Services Digital Network (ISDN).

8. The telemedicine system of claim 1, wherein the network is a local area network (LAN).

9. The telemedicine system of claim 1, wherein the network is a wide area network (WAN).

10. The telemedicine system of claim 1, wherein the network is a hybrid network consisting of a combination of one or more networks selected from the group consisting of: a community access television (CATV) network, an asynchronous transfer mode (ATM) network, the Internet, a Public Swiched Telephone Network (PSTN), an Integrated Services Digital Network (ISDN), a local area network (LAN), or a wide area network (WAN).

11. The telemedicine system of claim 1, wherein the first control unit receives video and voice data from videoconferencing equipment in communication with the control unit and delivers the video and voice data to the first communication device, the communication device encapsulating the video and voice data in packets in accordance with the preselected communications protocol and outputting the packets onto the network, wherein the second communication device receives the packets encapsulating the video and voice data and de-encapsulates the packets to reconstruct the video and voice data, the second communication device providing the video and voice data to the second control unit.

12. The telemedicine system of claim 3, wherein the communications protocol is TCP/IP.

13. The telemedicine system of claim 4, wherein the communications protocol is TCP/IP.

14. The telemedicine system of claim 5, wherein the communications protocol is TCP/IP.

15. The telemedicine system of claim 6, wherein the communications protocol is TCP/IP.

16. The telemedicine system of claim 7, wherein the communications protocol is TCP/IP.

17. The telemedicine system of claim 8, wherein the communications protocol is TCP/IP.

18. The telemedicine system of claim 9, wherein the communications protocol is TCP/IP.

19. The telemedicine system of claim 10, wherein the communications protocol is TCP/IP.

20. A method of acquiring and transporting data in a telemedicine system, the method comprising the steps of:

obtaining measurement data from at least one medical device located at a patient monitoring station, the measurement data representing a measurement of a physical condition of a patient, the measurement data being represented by one or more bits;

encapsulating the data in packets in accordance with a preselected communications protocol, each packet comprising a designation of a central monitoring station to which the packet is being sent;

outputting the packets onto a network;

receiving the packets at the central monitoring station designated by the designation comprised in the packets;

de-encapsulating the packets to reconstruct the data representing the physical condition of the patient; and

providing the reconstructed measurement data representing the physical condition to a control unit located at the central monitoring station.

21. The method of claim 20, further comprising the steps of:

obtaining video and voice data from videoconferencing equipment located at a patient monitoring station;

encapsulating the video and voice data in packets in accordance with the preselected communications protocol, each packet comprising a designation of the central monitoring station;

outputting the packets onto the network;

receiving the packets at the central monitoring station;

de-encapsulating the packets to reconstruct the video and voice data; and

providing the reconstructed video and voice data to the control unit located at the central monitoring station.

22. The method of claim 20, wherein the packets output onto the network comprise a medical record and wherein the medical record comprises an indication of the patient's identity and of the type of measurement data comprised in the medical record.

23. The method of claim 21, wherein the packets comprising the measurement data output onto the network comprise a medical record and wherein the medical record comprises an indication of the patient's identity and of the type of measurement data comprised in the medical record.

24. The method of claim 23, wherein the medical record further comprises an indication of the type of medical device from which the measurement data was obtained and an indication of a network address of the patient monitoring station.

25. A method of acquiring and transporting data in a telemedicine system, the method comprising the steps of:

generating medical device command data and application-level data in a control unit located at a central monitoring station, the data being represented by one or more bits;

encapsulating the data in packets in accordance with a preselected communications protocol, each packet comprising a designation of a patient monitoring station to which the packet is being sent;

outputting the packets onto a network;

receiving the packets at the patient monitoring station designated by the designation comprised in the packets;

de-encapsulating the packets to reconstruct the data; and

providing the reconstructed data to a control unit located at the patient monitoring station.

26. The method of claim 25, further comprising the steps of:

obtaining video and voice data from videoconferencing equipment located at the central monitoring station;

encapsulating the video and voice data in packets in accordance with the preselected communications protocol, each packet comprising the designation of the patient monitoring station;

outputting the packets onto the network;

receiving the packets at the patient monitoring station;

de-encapsulating the packets to reconstruct the video and voice data; and

providing the reconstructed video and voice data to the control unit located at the patient monitoring station.

27. A data signal for use in a telemedicine system, the data signal relating to a measurement obtained from medical equipment located at a patient monitoring station, the measurement corresponding to a physical condition of a patient, wherein the data signal is provided to a communication device which generates packets of data to be sent over a network, the data signal provided to the communication device comprising:

a plurality of bits representing the measurement;

a plurality of bits representing the patient's identity; and

a plurality of bits representing the type of measurement obtained from the medical equipment.

28. The data signal of claim 27 further comprising:

a plurality of bits representing the date and time at which the measurement was obtained;

a plurality of bits representing the type of medical equipment used to obtain the measurement; and

a plurality of bits representing the location of the medical equipment on the network.

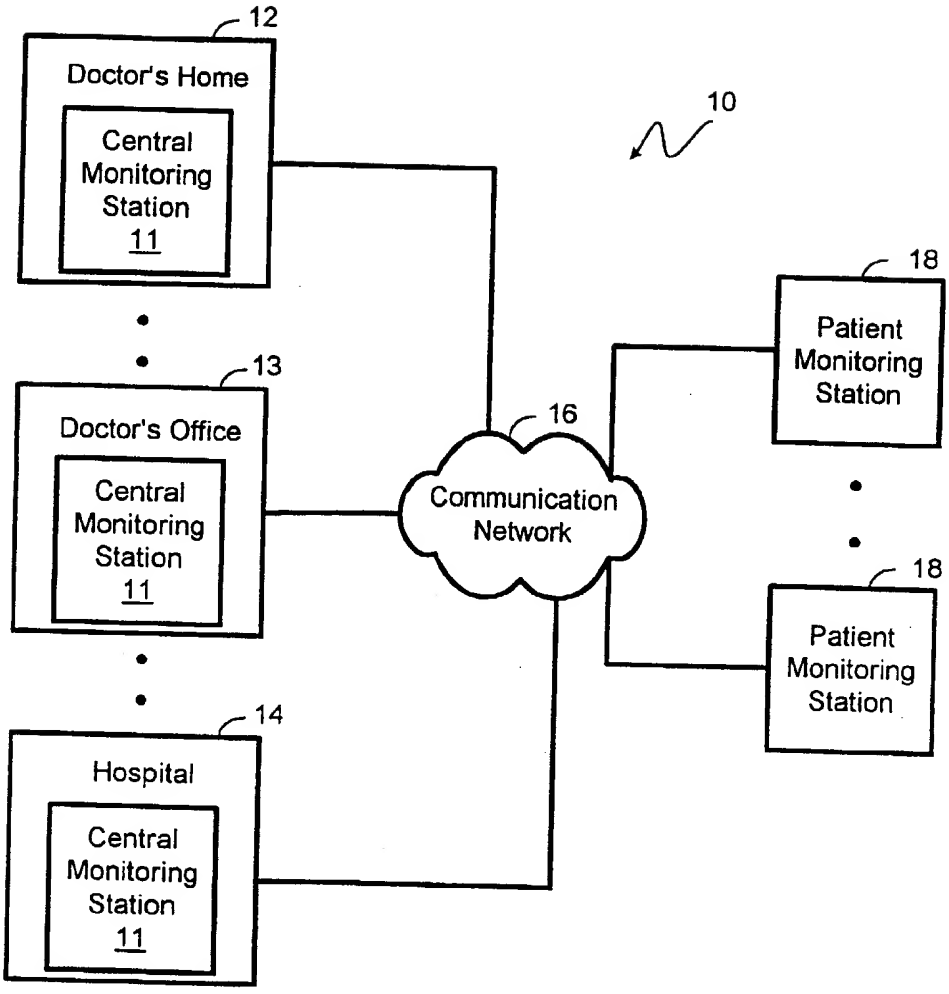
12
Doctor's Home
Central Monitoring Station 11
10
18
Patient Monitoring Station
13
Doctor's Office
Central Monitoring Station 11
16
Communication Network
18
Patient Monitoring Station
14
Hospital
Central Monitoring Station 11

Fig. 1

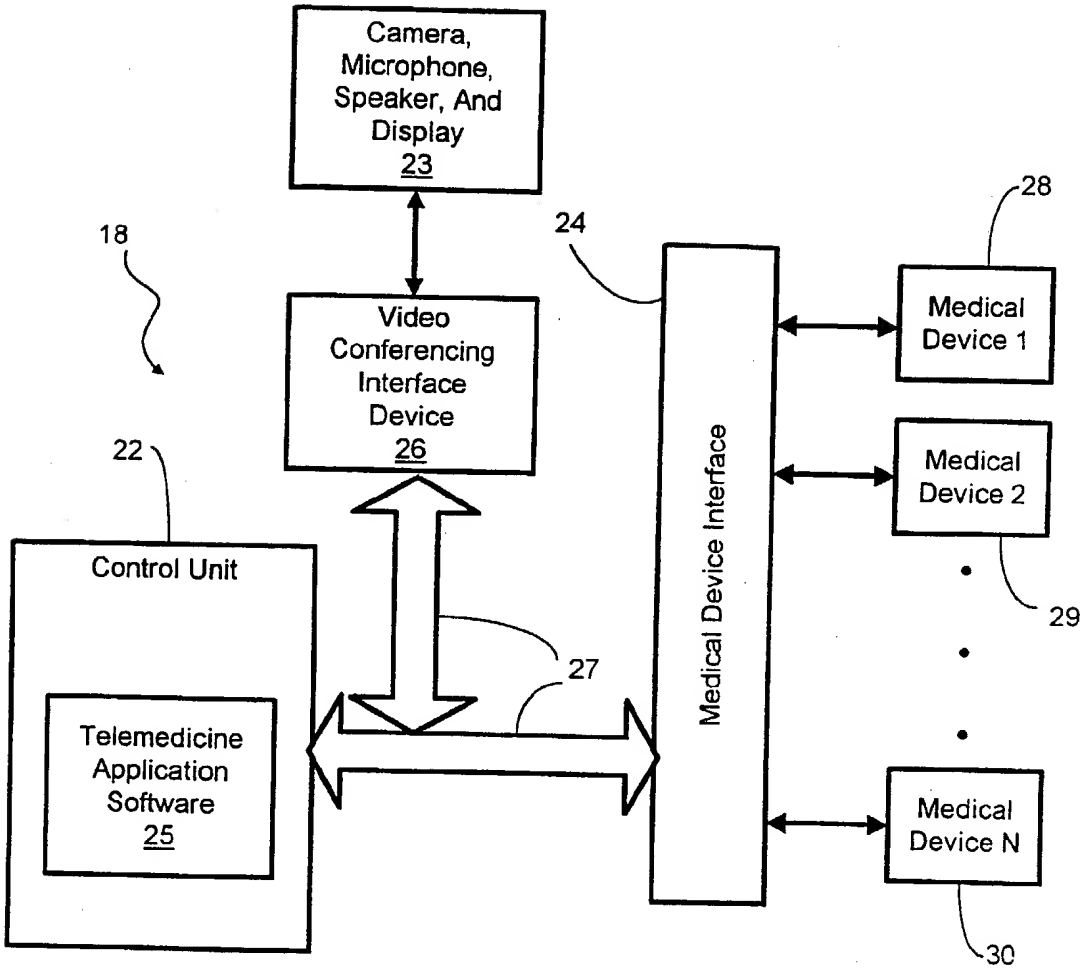
Camera, Microphone, Speaker, And Display 23
18
24
28
Video Conferencing Interface Device 26
Medical Device 1
Medical Device 2
22
Control Unit
29
27
Medical Device Interface
Telemedicine Application Software 25
Medical Device N
30

Fig. 2

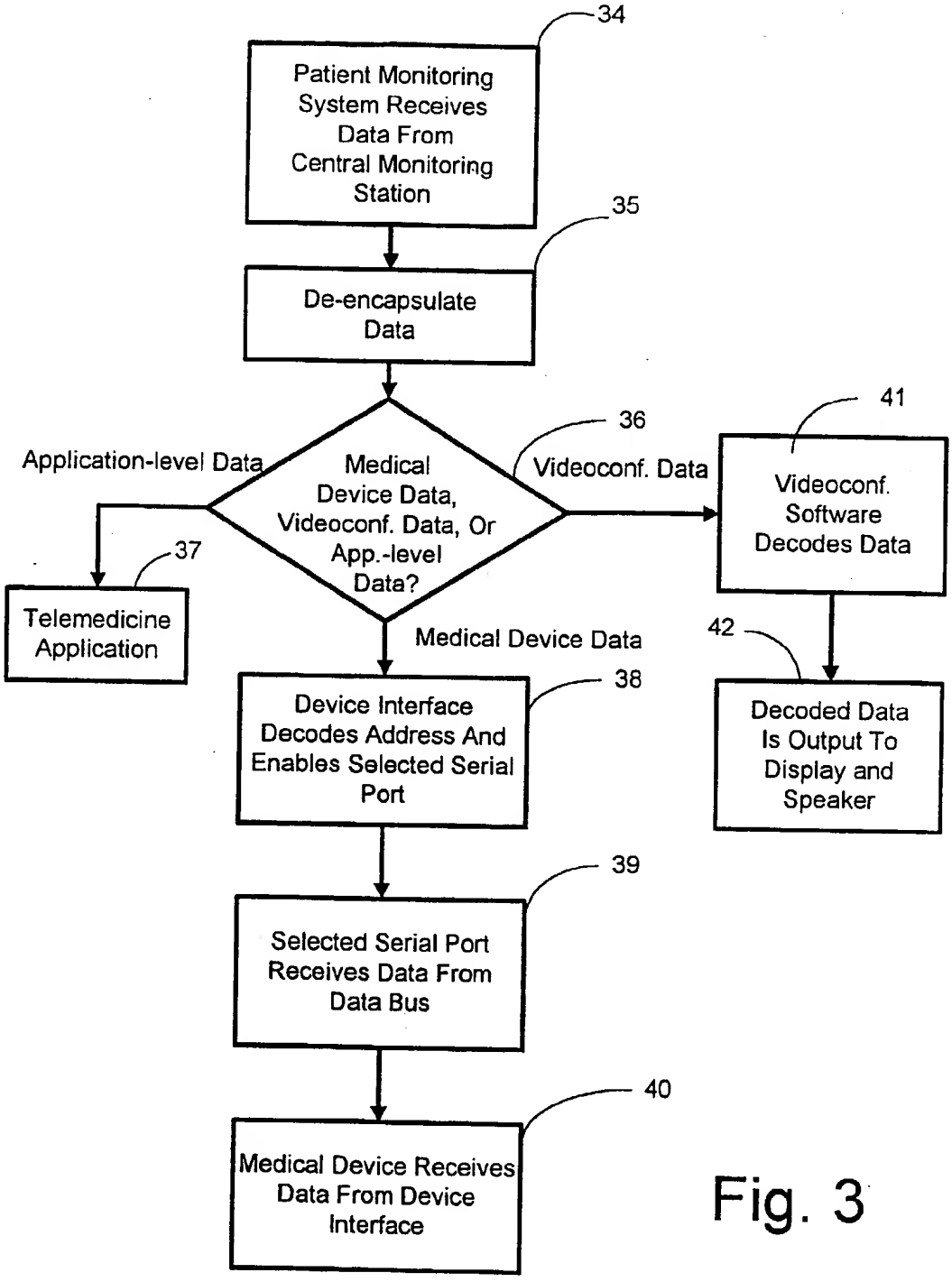
34
Patient Monitoring System Receives Data From Central Monitoring Station
35
De-encapsulate Data
36
Medical Device Data, Videoconf. Data, Or App.-level Data?
Application-level Data
Videoconf. Data
Medical Device Data
37
Telemedicine Application
41
Videoconf. Software Decodes Data
42
Decoded Data Is Output To Display and Speaker
38
Device Interface Decodes Address And Enables Selected Serial Port
39
Selected Serial Port Receives Data From Data Bus
40
Medical Device Receives Data From Device Interface

Fig. 3

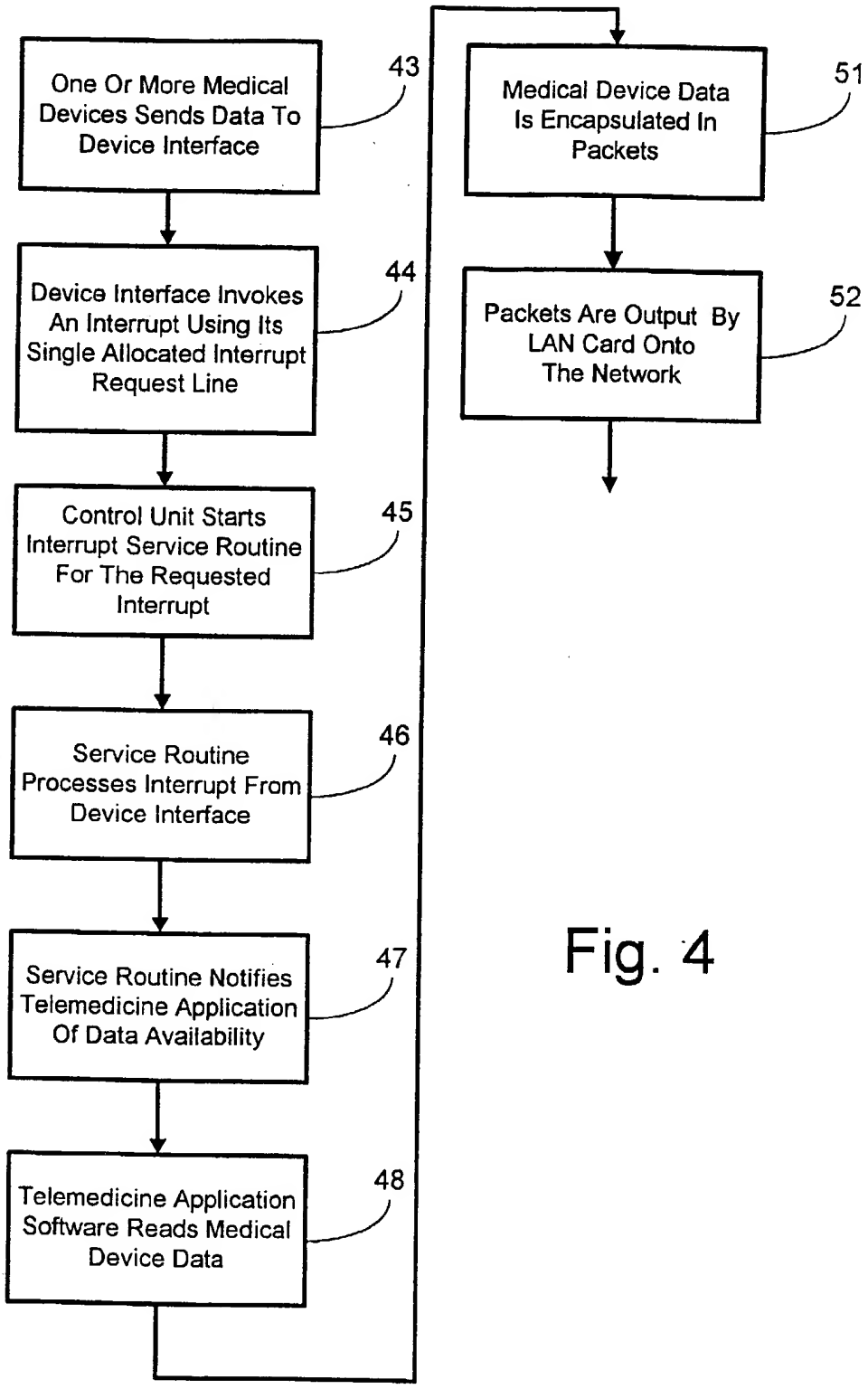
One Or More Medical Devices Sends Data To Device Interface
43
Device Interface Invokes An Interrupt Using Its Single Allocated Interrupt Request Line
44
Control Unit Starts Interrupt Service Routine For The Requested Interrupt
45
Service Routine Processes Interrupt From Device Interface
46
Service Routine Notifies Telemedicine Application Of Data Availability
47
Telemedicine Application Software Reads Medical Device Data
48
Medical Device Data Is Encapsulated In Packets
51
Packets Are Output By LAN Card Onto The Network
52

Fig. 4

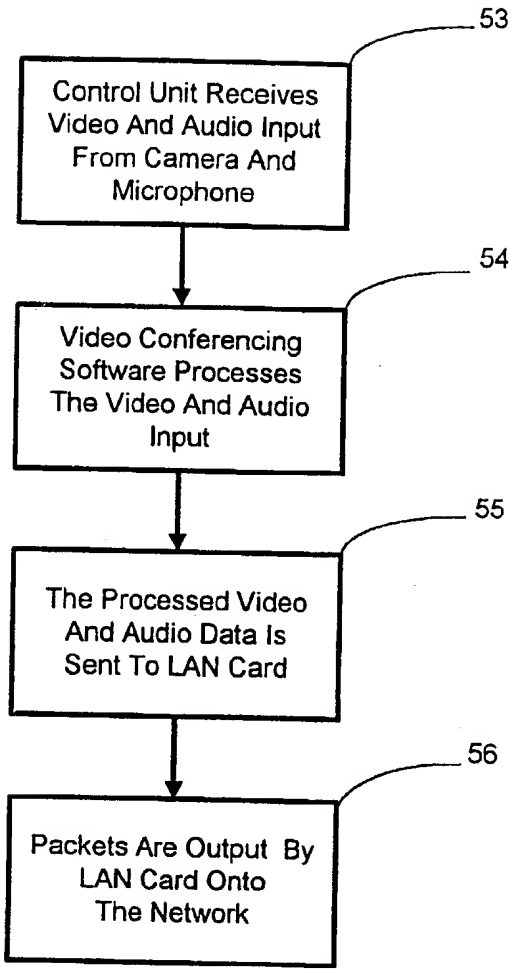
53
Control Unit Receives Video And Audio Input From Camera And Microphone
54
Video Conferencing Software Processes The Video And Audio Input
55
The Processed Video And Audio Data Is Sent To LAN Card
56
Packets Are Output By LAN Card Onto The Network

Fig. 5

US005807336A

United States Patent [19]

Russo et al.

[11] Patent Number: 5,807,336

[45] Date of Patent: Sep. 15, 1998

[54] **APPARATUS FOR MONITORING AND/OR CONTROLLING A MEDICAL DEVICE**

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[73] Assignee: **Sabratek Corporation**, Niles, Ill.

[21] Appl. No.: **691,872**

[22] Filed: **Aug. 2, 1996**

[51] **Int. Cl.**[6] **A61M 31/00**

[52] **U.S. Cl.** **604/131**; 604/207; 604/246

[58] **Field of Search** 604/31, 50, 65, 604/66, 67, 93, 131, 207, 246

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5,400,246	3/1995	Wilson et al.	364/146
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(List continued on next page.)

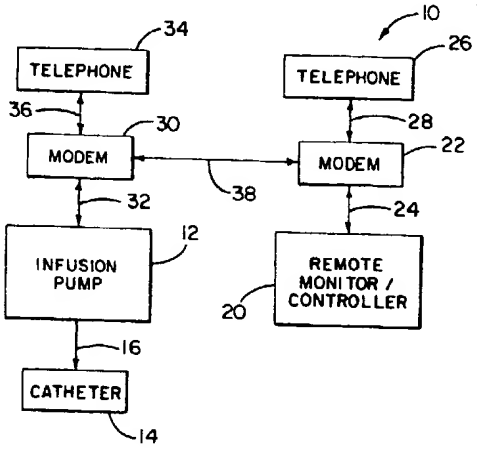
Primary Examiner—Max Hindenburg

Attorney, Agent, or Firm—Fitch, Even, Tabin & Flannery

[57] **ABSTRACT**

A medical apparatus is provided with a programmable medical device disposed at a first room location and a remote monitor and/or controller disposed at a second room location. The programmable medical device is used to administer a medical treatment to a patient, and the remote monitor/controller may be used to monitor the operation of the medical device, control the operation of the medical device, and/or to transfer data from the medical device to the remote monitor/controller. The apparatus may allow voice communication between the remote monitor/controller and the patient who is receiving treatment via the medical device while the medical device is being monitored and/or controlled from the remote location. The remote monitor/controller may also include means for determining the type of medical device to which it is connected.

19 Claims, 12 Drawing Sheets



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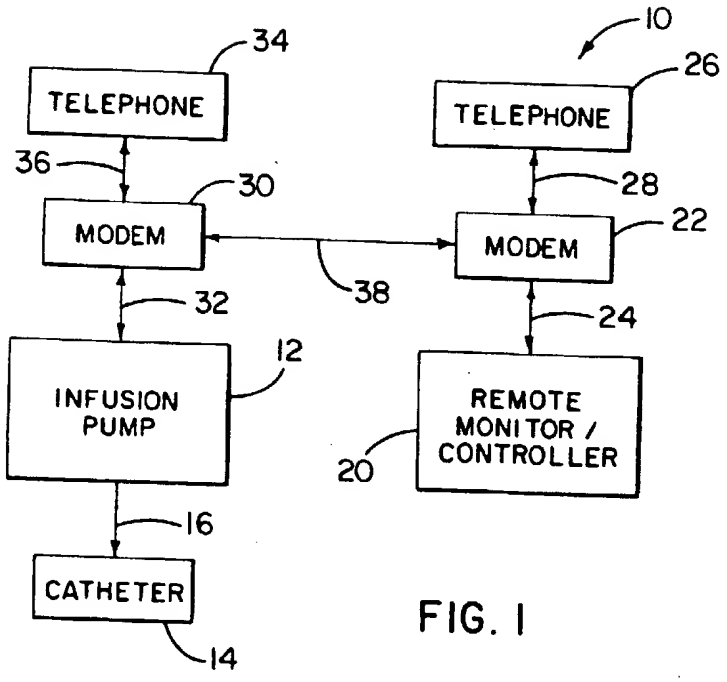

10
34
TELEPHONE
26
TELEPHONE
36
30
28
MODEM
22
MODEM
38
32
24
12
INFUSION PUMP
REMOTE MONITOR / CONTROLLER
20
16
CATHETER
14

FIG. 1

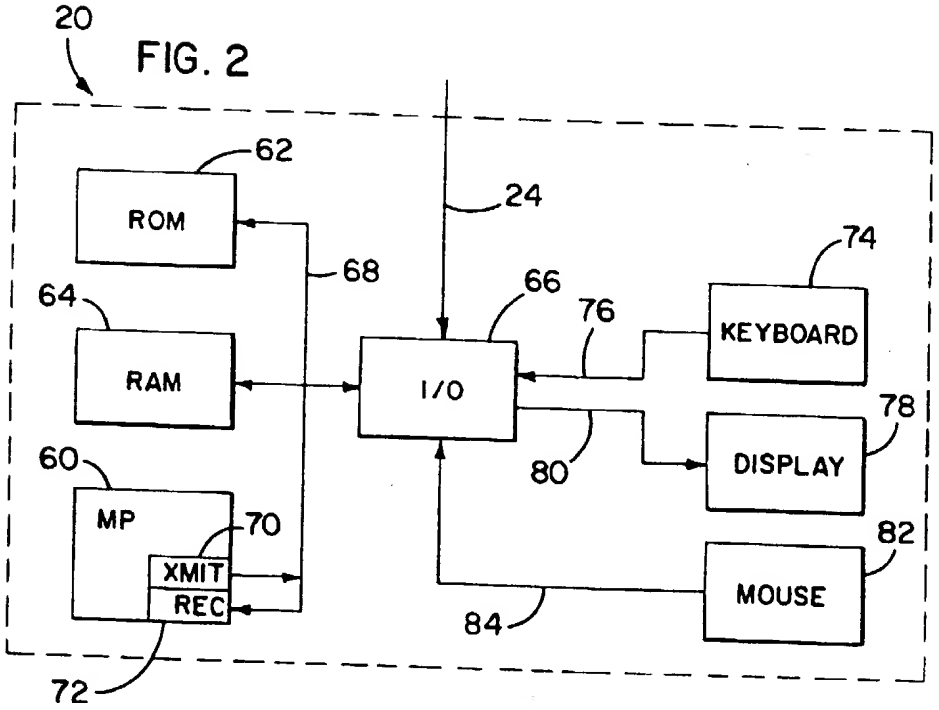

20
62
ROM
24
68
74
64
66
76
RAM
I/O
KEYBOARD
78
60
80
DISPLAY
MP
70
82
XMIT
REC
MOUSE
84
72

FIG. 2

FIG. 3

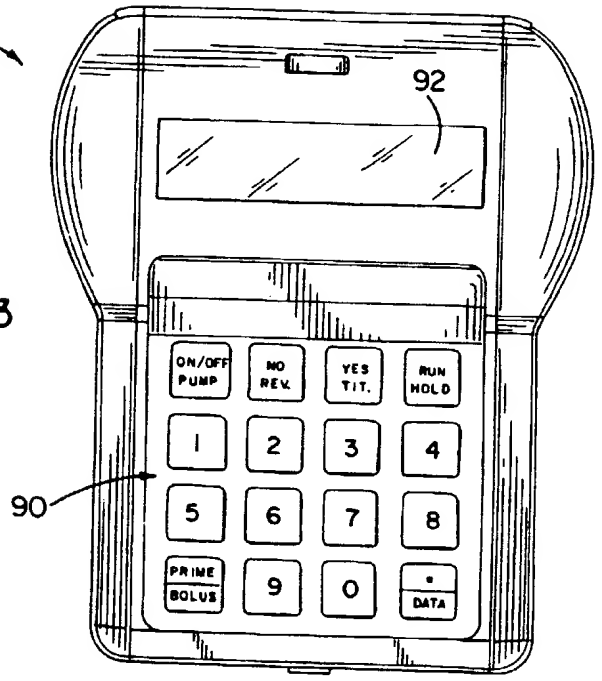

12
92
90
ON/OFF PUMP
NO REV.
YES T.T.
RUN HOLD
1
2
3
4
5
6
7
8
PRIME BOLUS
9
0
DATA

FIG. 4

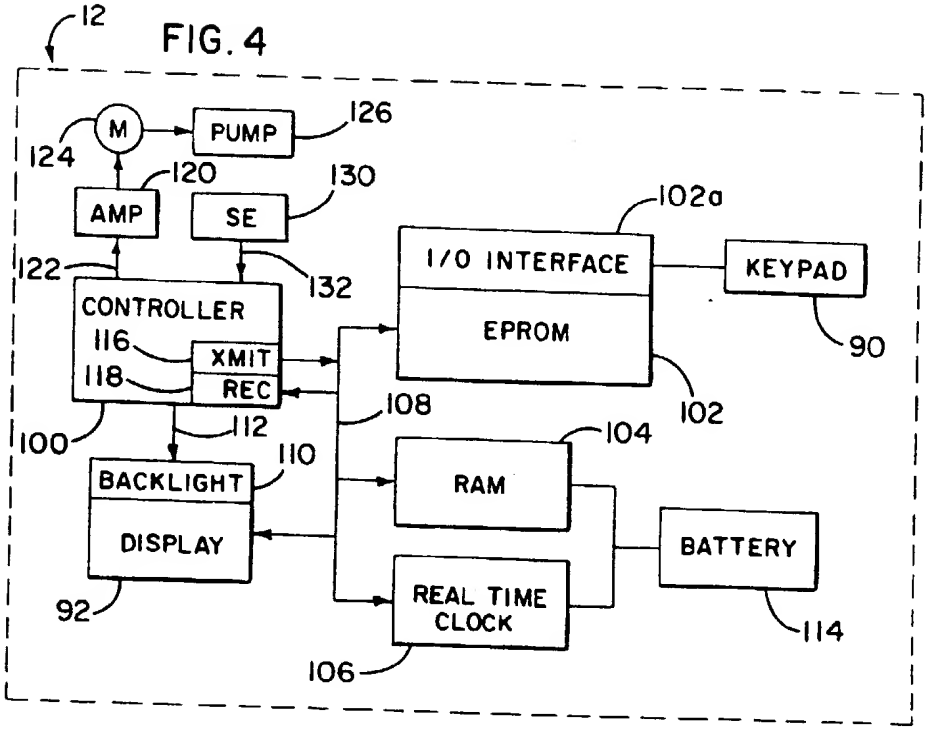

12
M
PUMP
126
124
120
130
AMP
SE
102a
I/O INTERFACE
KEYPAD
122
132
CONTROLLER
EPROM
90
116
XMIT
118
REC
108
102
100
112
104
110
BACKLIGHT
RAM
DISPLAY
BATTERY
92
REAL TIME CLOCK
114
106

FIG. 5

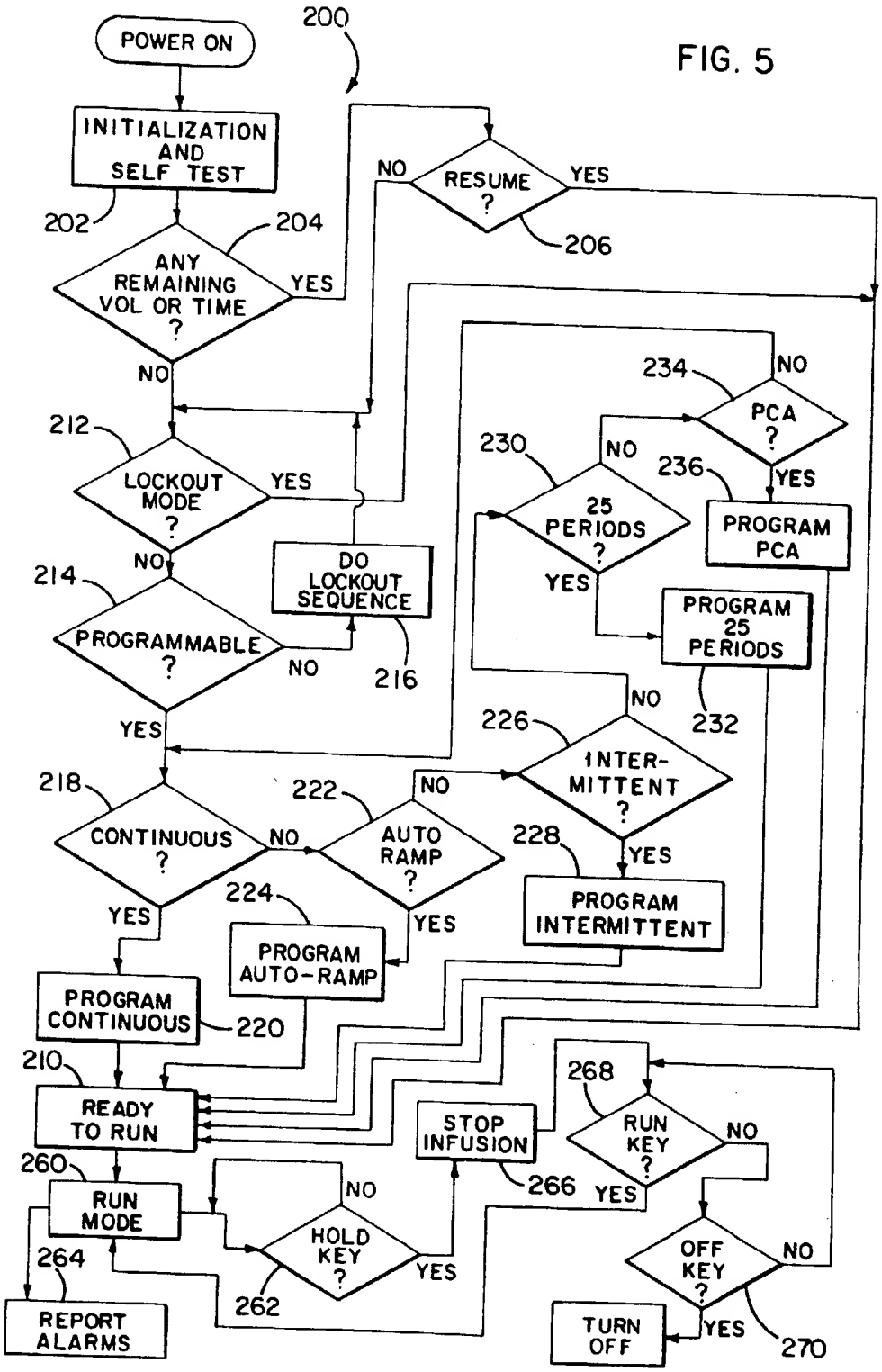
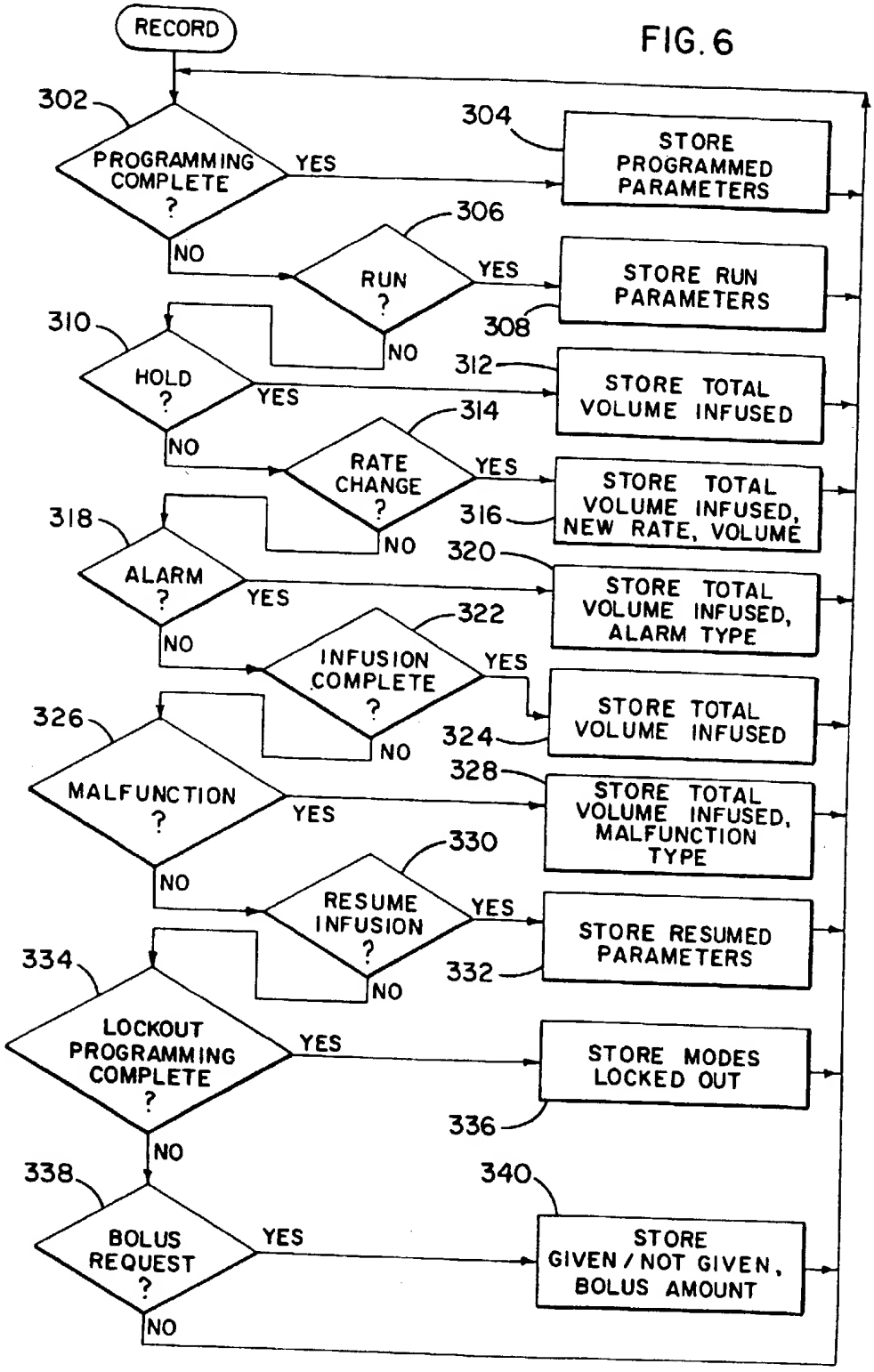

200
POWER ON
INITIALIZATION AND SELF TEST
202
RESUME ?
NO
YES
206
204
ANY REMAINING VOL OR TIME ?
YES
NO
212
LOCKOUT MODE ?
YES
NO
DO LOCKOUT SEQUENCE
214
PROGRAMMABLE ?
NO
216
YES
218
CONTINUOUS ?
NO
YES
222
AUTO RAMP ?
NO
YES
224
PROGRAM AUTO-RAMP
PROGRAM CONTINUOUS
220
234
PCA ?
NO
YES
230
25 PERIODS ?
NO
YES
236
PROGRAM PCA
PROGRAM 25 PERIODS
232
226
INTER-MITTENT ?
NO
YES
228
PROGRAM INTERMITTENT
210
READY TO RUN
260
RUN MODE
264
REPORT ALARMS
HOLD KEY ?
NO
YES
262
STOP INFUSION
266
268
RUN KEY ?
NO
YES
OFF KEY ?
NO
YES
TURN OFF
270

FIG. 6


RECORD
302
PROGRAMMING COMPLETE ?
YES
304
STORE PROGRAMMED PARAMETERS
NO
306
RUN ?
YES
STORE RUN PARAMETERS
NO
308
310
HOLD ?
YES
312
STORE TOTAL VOLUME INFUSED
NO
314
RATE CHANGE ?
YES
STORE TOTAL VOLUME INFUSED, NEW RATE, VOLUME
316
NO
318
ALARM ?
YES
320
STORE TOTAL VOLUME INFUSED, ALARM TYPE
NO
322
INFUSION COMPLETE ?
YES
STORE TOTAL VOLUME INFUSED
324
NO
326
MALFUNCTION ?
YES
328
STORE TOTAL VOLUME INFUSED, MALFUNCTION TYPE
NO
330
RESUME INFUSION ?
YES
STORE RESUMED PARAMETERS
332
NO
334
LOCKOUT PROGRAMMING COMPLETE ?
YES
STORE MODES LOCKED OUT
336
NO
338
BOLUS REQUEST ?
YES
340
STORE GIVEN / NOT GIVEN, BOLUS AMOUNT
NO

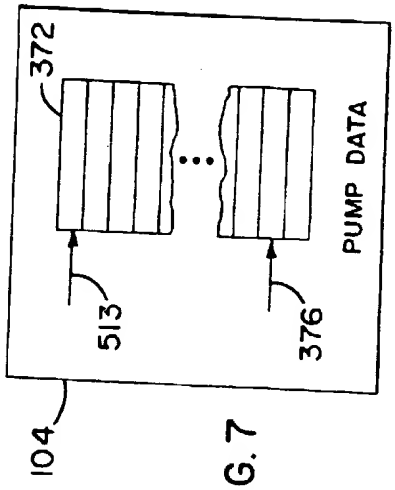

372
513
376
PUMP DATA
104

FIG. 7

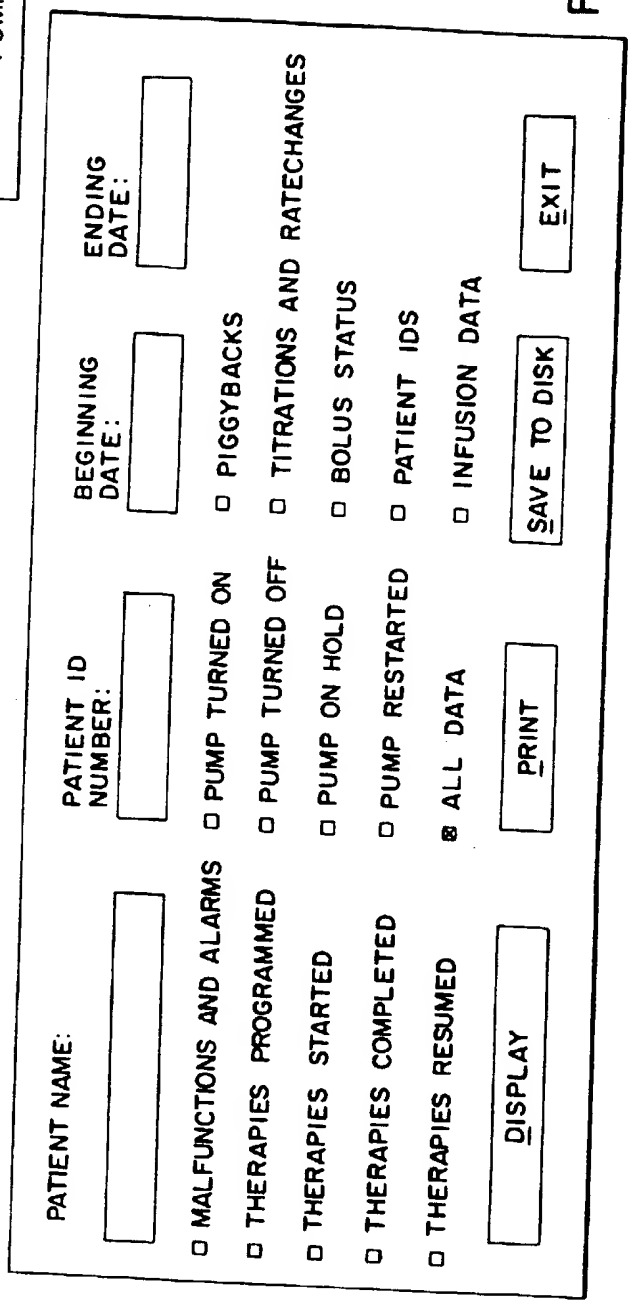

PATIENT NAME:
PATIENT ID NUMBER:
BEGINNING DATE:
ENDING DATE:
☐ MALFUNCTIONS AND ALARMS
☐ THERAPIES PROGRAMMED
☐ THERAPIES STARTED
☐ THERAPIES COMPLETED
☐ THERAPIES RESUMED
☐ PUMP TURNED ON
☐ PUMP TURNED OFF
☐ PUMP ON HOLD
☐ PUMP RESTARTED
☒ ALL DATA
☐ PIGGYBACKS
☐ TITRATIONS AND RATECHANGES
☐ BOLUS STATUS
☐ PATIENT IDS
☐ INFUSION DATA
DISPLAY
PRINT
SAVE TO DISK
EXIT

FIG. 15

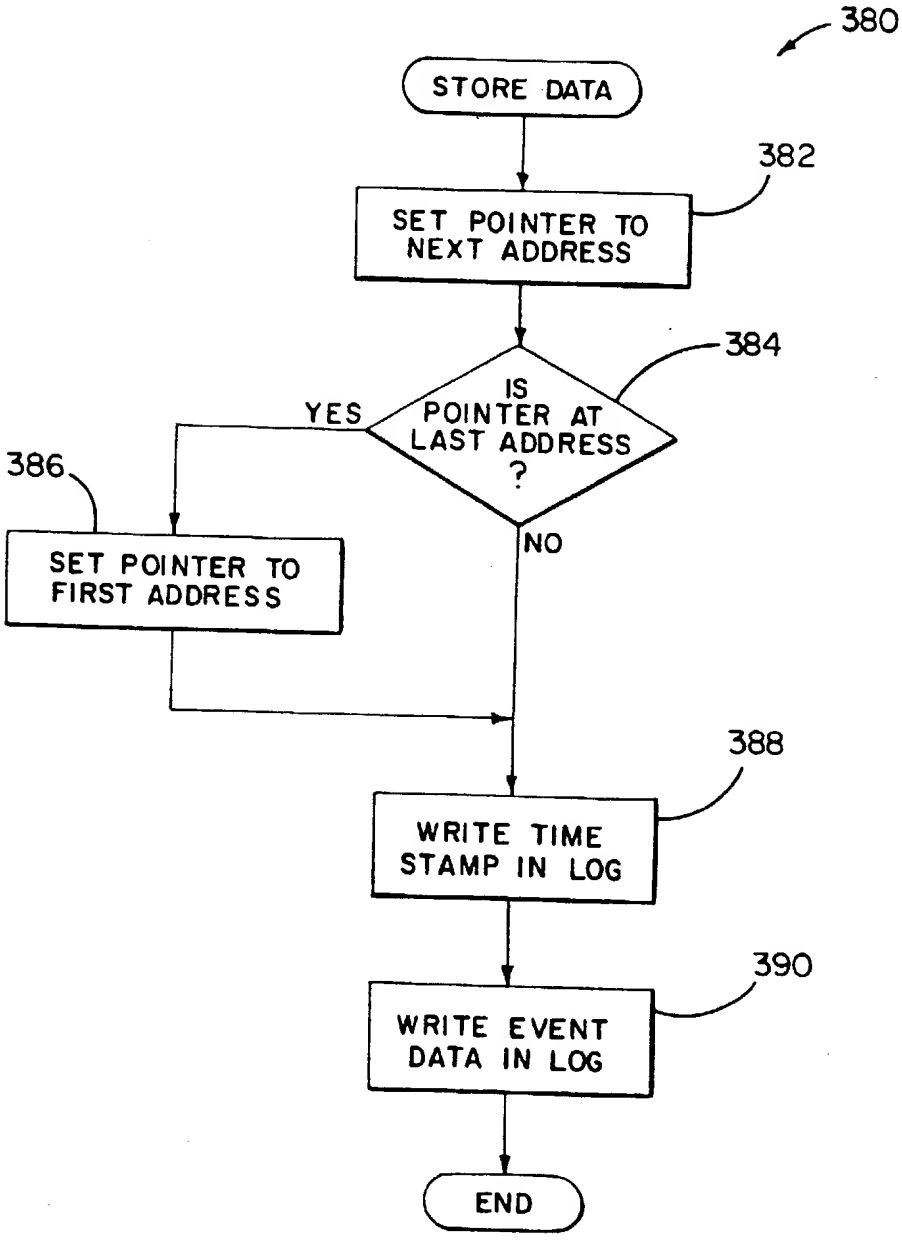

380
STORE DATA
382
SET POINTER TO NEXT ADDRESS
384
IS POINTER AT LAST ADDRESS ?
YES
NO
386
SET POINTER TO FIRST ADDRESS
388
WRITE TIME STAMP IN LOG
390
WRITE EVENT DATA IN LOG
END

FIG. 8

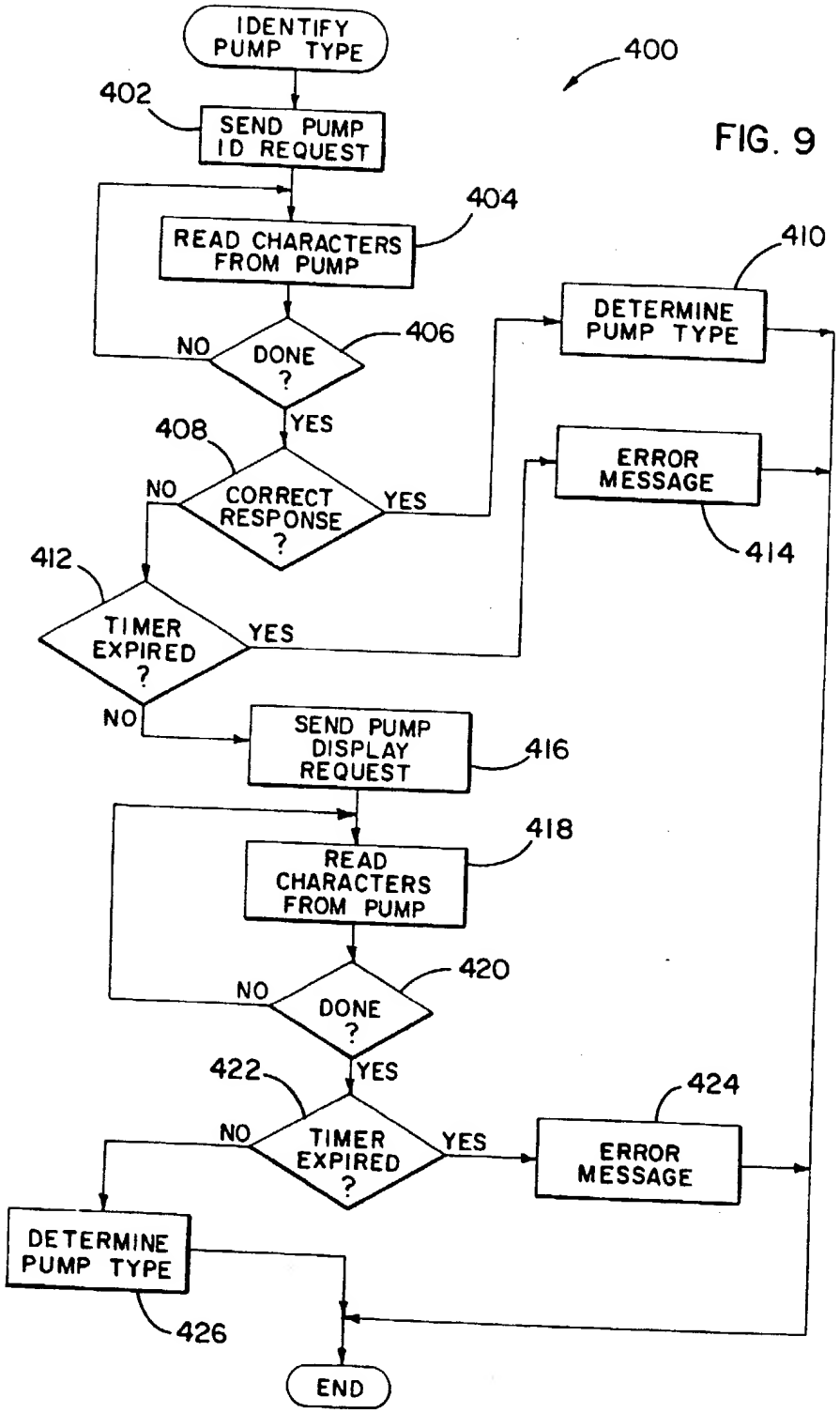

IDENTIFY PUMP TYPE
400
402
SEND PUMP ID REQUEST
404
READ CHARACTERS FROM PUMP
406
NO
DONE ?
YES
408
NO
CORRECT RESPONSE ?
YES
410
DETERMINE PUMP TYPE
ERROR MESSAGE
414
412
TIMER EXPIRED ?
YES
NO
SEND PUMP DISPLAY REQUEST
416
418
READ CHARACTERS FROM PUMP
420
NO
DONE ?
YES
422
NO
TIMER EXPIRED ?
YES
424
ERROR MESSAGE
DETERMINE PUMP TYPE
426
END

FIG. 9

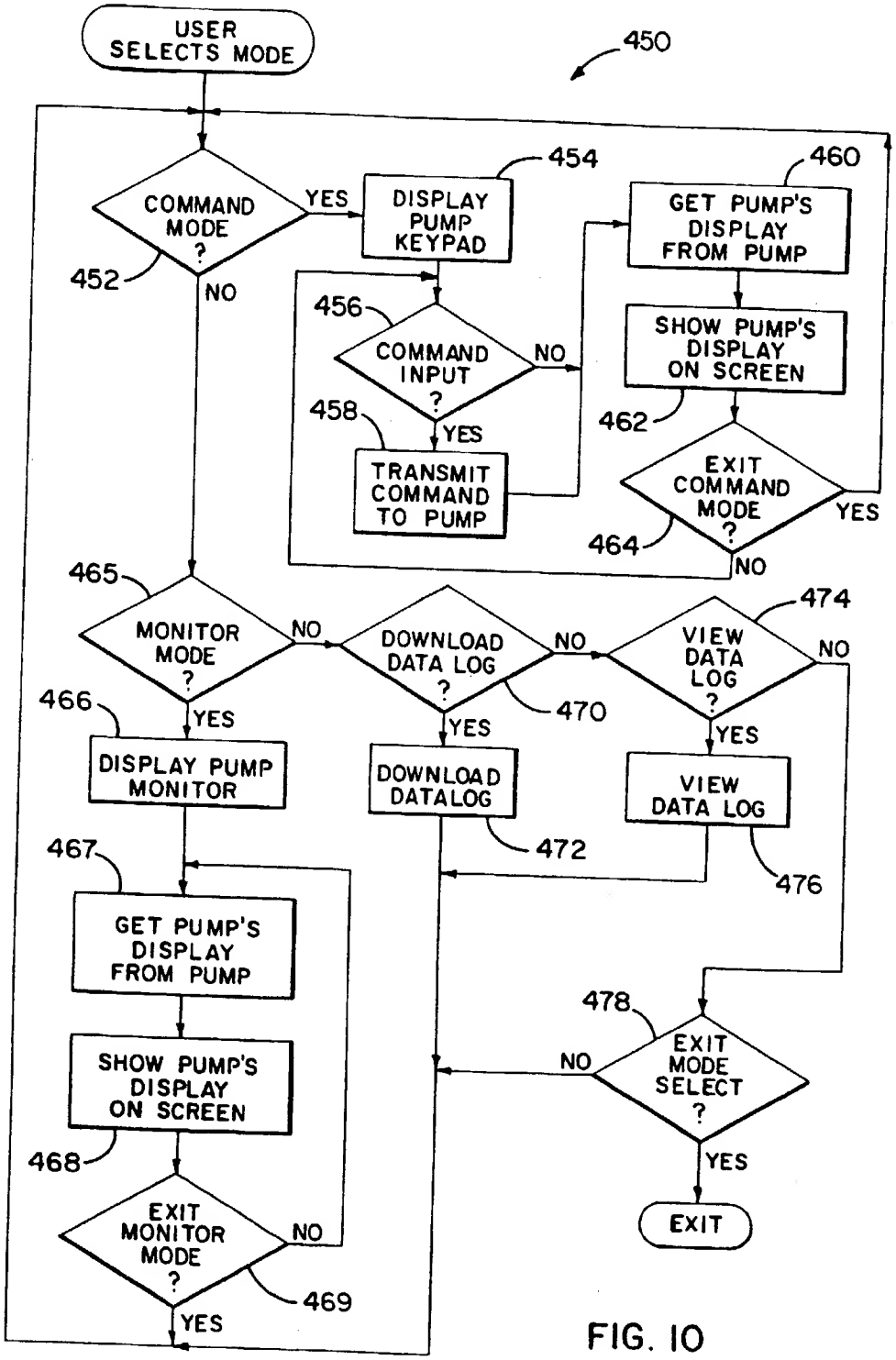

USER SELECTS MODE
450
COMMAND MODE ?
YES
NO
452
DISPLAY PUMP KEYPAD
454
COMMAND INPUT ?
456
NO
YES
458
TRANSMIT COMMAND TO PUMP
GET PUMP'S DISPLAY FROM PUMP
460
SHOW PUMP'S DISPLAY ON SCREEN
462
EXIT COMMAND MODE ?
464
YES
NO
MONITOR MODE ?
465
NO
YES
466
DISPLAY PUMP MONITOR
DOWNLOAD DATA LOG ?
NO
YES
470
DOWNLOAD DATALOG
472
VIEW DATA LOG ?
474
NO
YES
VIEW DATA LOG
476
GET PUMP'S DISPLAY FROM PUMP
467
SHOW PUMP'S DISPLAY ON SCREEN
468
EXIT MONITOR MODE ?
NO
YES
469
EXIT MODE SELECT ?
478
NO
YES
EXIT

FIG. 10

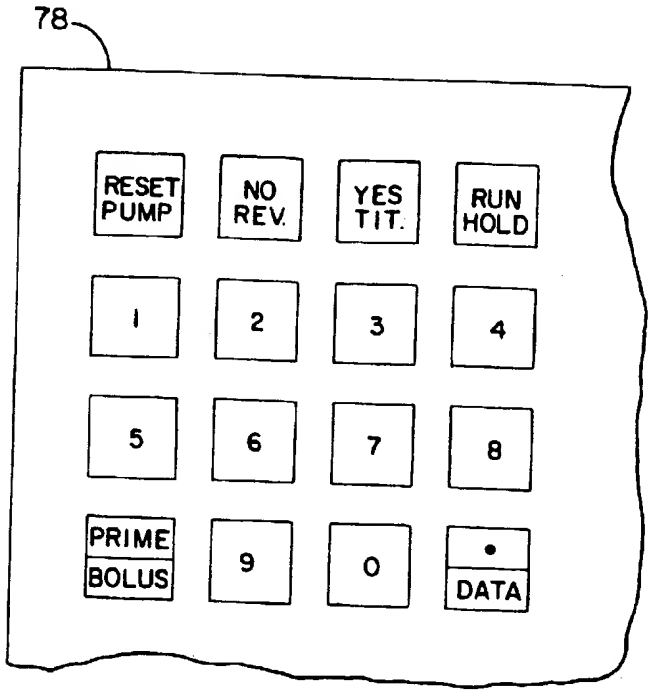


FIG. 11A

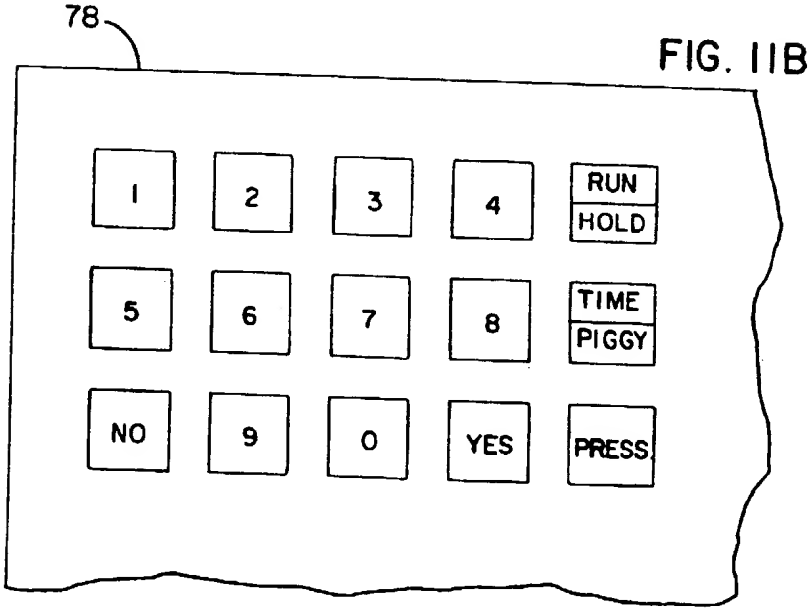


FIG. 11B

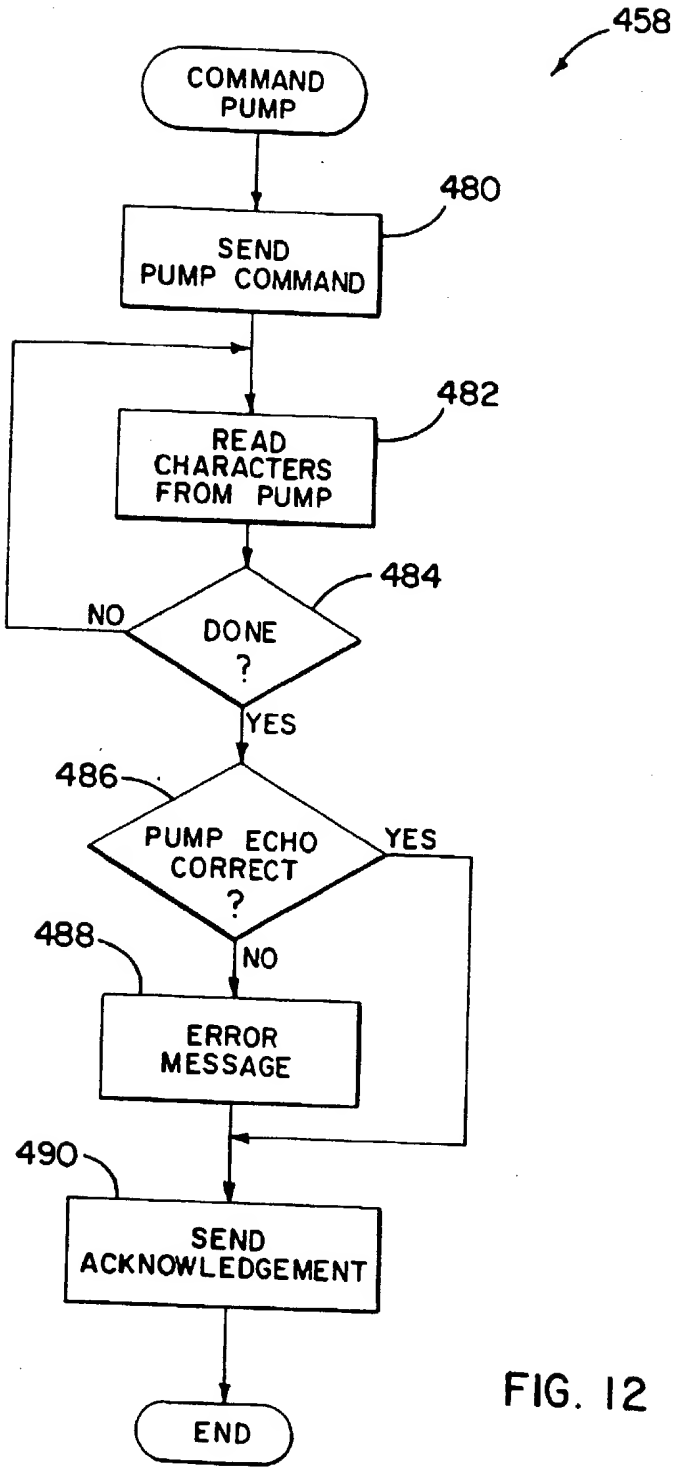

458
COMMAND PUMP
480
SEND PUMP COMMAND
482
READ CHARACTERS FROM PUMP
484
DONE ?
NO
YES
486
PUMP ECHO CORRECT ?
YES
NO
488
ERROR MESSAGE
490
SEND ACKNOWLEDGEMENT
END

FIG. 12

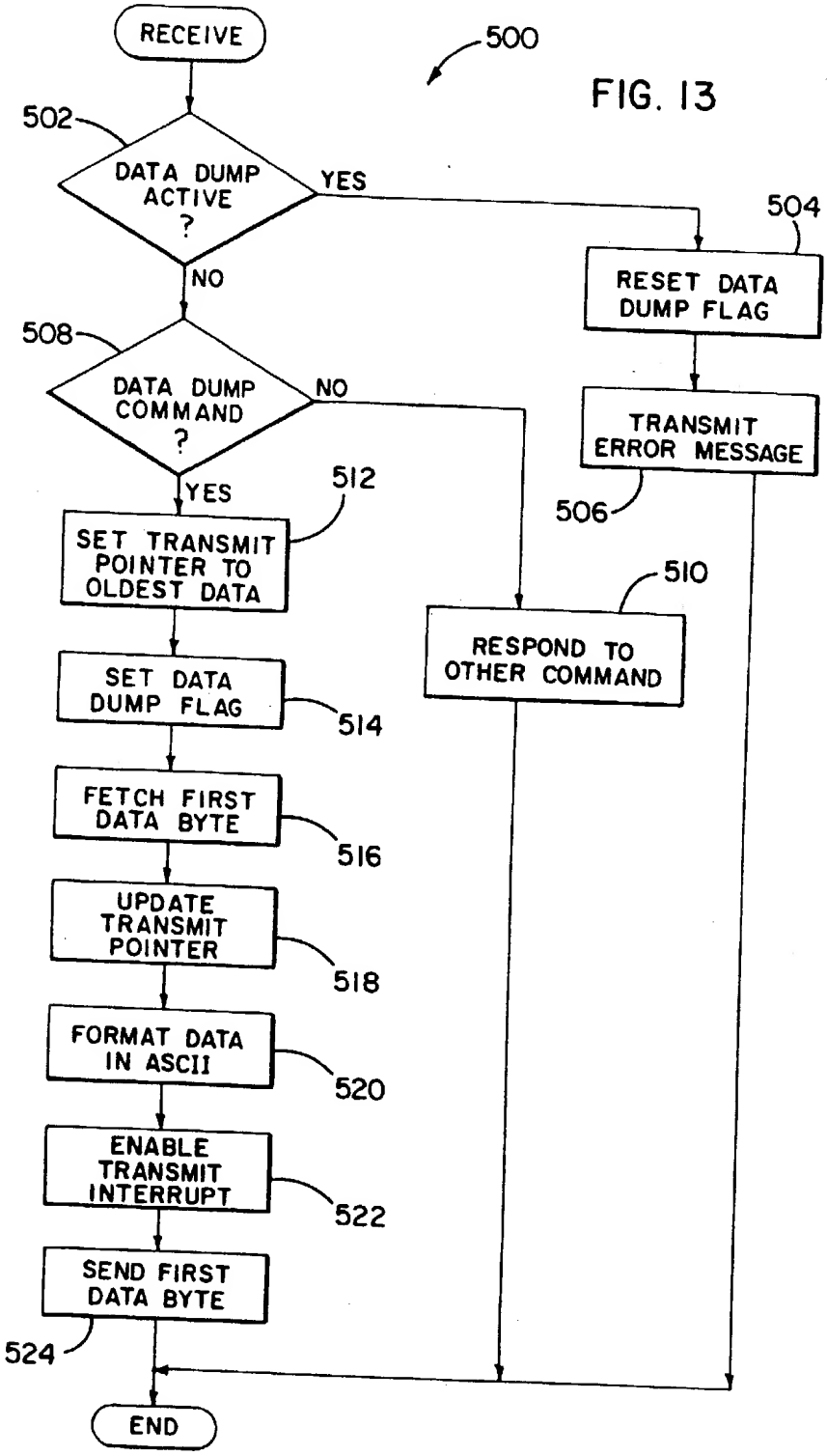

RECEIVE
500
502
DATA DUMP ACTIVE ?
YES
504
RESET DATA DUMP FLAG
NO
508
DATA DUMP COMMAND ?
NO
TRANSMIT ERROR MESSAGE
506
YES
512
SET TRANSMIT POINTER TO OLDEST DATA
510
RESPOND TO OTHER COMMAND
SET DATA DUMP FLAG
514
FETCH FIRST DATA BYTE
516
UPDATE TRANSMIT POINTER
518
FORMAT DATA IN ASCII
520
ENABLE TRANSMIT INTERRUPT
522
SEND FIRST DATA BYTE
524
END

FIG. 13

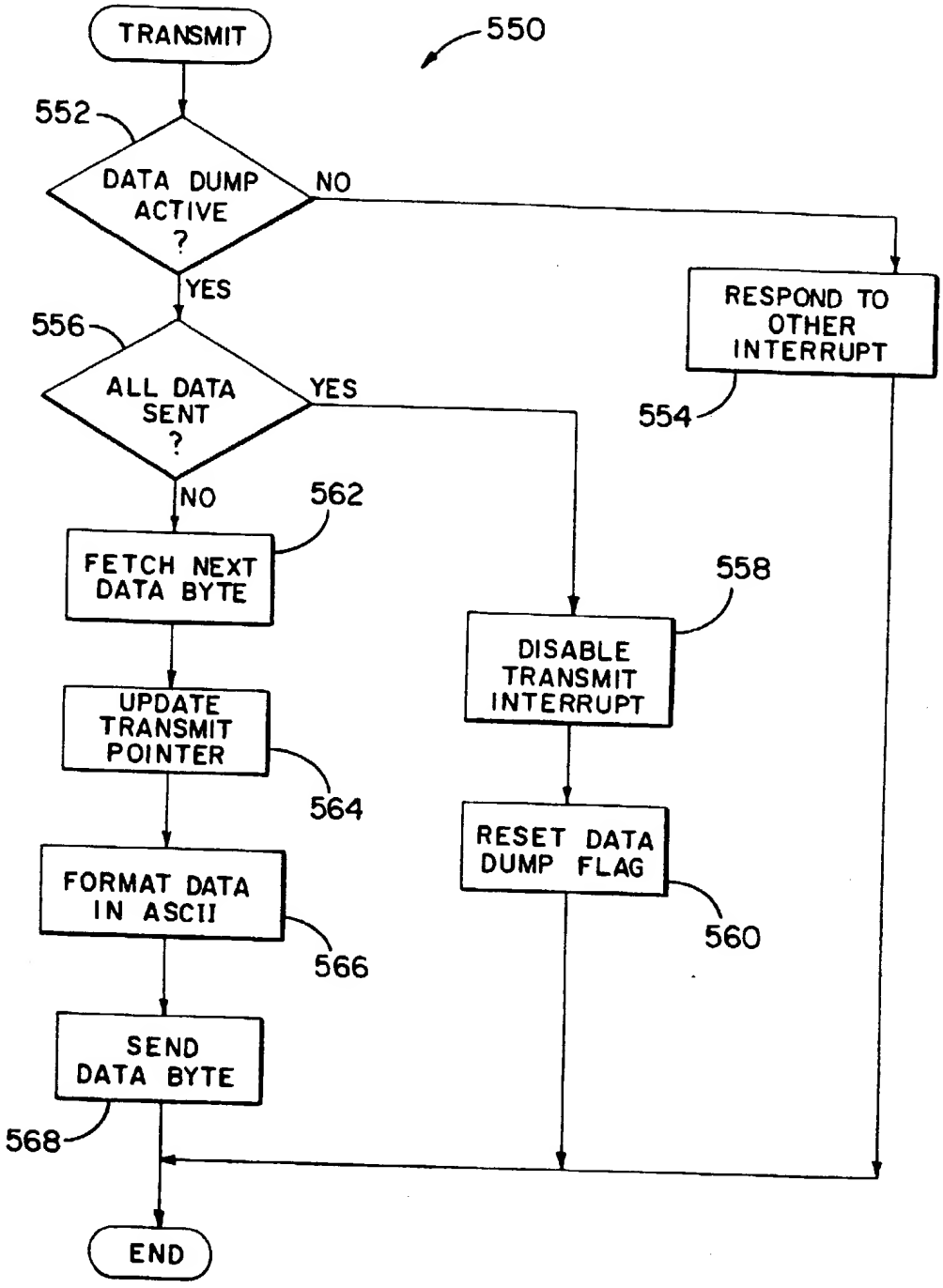

TRANSMIT
550
552
DATA DUMP ACTIVE ?
NO
YES
RESPOND TO OTHER INTERRUPT
554
556
ALL DATA SENT ?
YES
NO
562
FETCH NEXT DATA BYTE
558
DISABLE TRANSMIT INTERRUPT
UPDATE TRANSMIT POINTER
564
RESET DATA DUMP FLAG
560
FORMAT DATA IN ASCII
566
SEND DATA BYTE
568
END

FIG. 14

APPARATUS FOR MONITORING AND/OR CONTROLLING A MEDICAL DEVICE

BACKGROUND OF THE INVENTION

The present invention is directed to an apparatus for monitoring and/or controlling a medical device, such as an infusion pump, from a remote location.

An infusion pump is used to automatically administer liquid medicant to a patient. The liquid medicant is supplied from a source of medicant and pumped into the patient via a catheter or other injection device. The manner in which the liquid is infused is controlled by the infusion pump, which may have various modes of infusion, such as a continuous mode in which the liquid medicant is continuously infused at a constant rate, or a ramp mode in which the rate of infusion gradually increases, then remains constant, and then gradually decreases.

Typically, the monitoring of an infusion pump is performed by reviewing a visual display means incorporated in the infusion pump, and the control of the infusion pump is performed by activating an input device, such as a keypad, incorporated with the infusion pump. Consequently, the monitoring and/or control of an infusion pump is performed at the same location at which the infusion pump is disposed.

SUMMARY OF THE INVENTION

The invention is generally directed to a medical apparatus having a programmable medical device disposed at a first room location and a remote monitor and/or controller disposed at a second room location.

In one aspect, the invention is directed to a medical apparatus having a medical device for administering a medical treatment to a patient, the medical device being disposed at a first room location and including means for administering the medical treatment to the patient and memory means for storing data regarding the medical treatment administered to the patient. The medical apparatus also includes a remote monitor for monitoring the medical treatment administered to the patient, the remote monitor being disposed at a second room location remote from the first room location, and means for transferring the data from the medical device to the remote monitor while the medical device is administering the medical treatment to the patient.

The data may be transmitted to the remote monitor in segmented, noncontinuous data portions, and the means for transferring the data to the remote monitor may include means for repeatedly transmitting portions of the data from the medical device to the remote monitor and means for generating an interrupt when one of the data portions has been transmitted to the remote monitor, the interrupt causing the transmitting means to transmit another of the data portions from the medical device to the remote monitor.

In a second aspect, the invention is directed to a medical apparatus having a medical device for administering a medical treatment to a patient, the medical device being disposed at a first room location and including means for administering the medical treatment to the patient and memory means for storing data regarding the medical treatment administered to the patient. The medical device also includes a remote monitor for monitoring the medical treatment administered to the patient, the remote monitor being disposed at a second room location remote from the first room location, a communication link operatively coupled between the medical device and the remote monitor, means for transferring the data from the medical device to the remote monitor via the communication link, and means for allowing voice communication between the medical device and the remote monitor via the communication link while the data is being transferred from the medical device to the remote monitor.

In a third aspect, the invention is directed to an apparatus having remote means for communicating with one of a plurality of medical devices each of which is designed to administer a medical treatment to a patient, the one medical device being disposed at a first room location and the remote means being disposed at a second room location remote from the first room location. The remote means includes means for automatically determining the type of the one programmable medical device and means for receiving data relating to the medical treatment of the patient after the type of the one programmable medical device has been determined. The apparatus also includes data communication means coupled to the remote means for transferring data between the remote means and the one programmable medical device.

The one programmable medical device may have a visual display device and the means for automatically determining the type of the one programmable medical device may include means for transmitting a display request to the one programmable medical device to request that the one programmable medical device transmit display data including a plurality of characters shown on the visual display device of the one programmable medical device, means for receiving the display data, and means for determining the type of the one programmable medical device based upon the display data.

The display data may include a number of characters and the determining means may include means for determining the type of the one programmable medical device based upon the number of characters in the display data. The means for automatically determining the type of the one programmable medical device may also include means of a first type for automatically determining the type of the one programmable medical device and means of a second type for automatically determining the type of the one programmable medical device.

These and other features and advantages of the present invention will be apparent to those of ordinary skill in the art in view of the detailed description of the preferred embodiment, which is made with reference to the drawings, a brief description of which is provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of an apparatus for administering medical treatment to a patient and monitoring the condition of the patient;

FIG. **2** is a block diagram of the electronic components of the remote monitor/controller shown schematically in FIG. **1**;

FIG. **3** is a front view of one embodiment of the infusion pump shown schematically in FIG. **1**;

FIG. **4** is a block diagram of the electronic components of the infusion pump of FIG. **3**;

FIG. **5** is a flowchart of the overall operation of the infusion pump;

FIG. **6** illustrates a number of data-recording steps performed during the operation of the infusion pump;

FIG. **7** is a representation of a portion of the memory of the infusion pump;

FIG. **8** is a flowchart of a store data routine which can be used to store data relating to the operation of the infusion pump and data relating to the condition of a patient;

FIG. 9 is a flowchart of a routine which may be used to identify the type of infusion pump to which the remote monitor/controller is coupled;

FIG. 10 is a flowchart of a mode select routine of the remote monitor/controller;

FIGS. 11A–11B illustrate portions of visual displays generated by the remote monitor/controller;

FIG. 12 is a flowchart of a command pump routine that is performed by the remote monitor/controller;

FIG. 13 is a flowchart of a receive routine that is performed by the infusion pump;

FIG. 14 is a flowchart of a transmit routine that is performed by the infusion pump; and

FIG. 15 is an illustration of a graphical user menu that may be displayed by the remote monitor/controller.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1 illustrates one embodiment of an apparatus **10** for administering medical treatment to a patient. Referring to FIG. 1, the apparatus **10** includes a programmable medical treatment means in the form of an infusion pump **12**, which is connected to a liquid medicant injection device in the form of a catheter **14** via a liquid conduit schematically shown as **16**.

The apparatus **10** includes a remote monitor/controller **20** which is disposed at a room location remote from the room location at which the infusion pump **12** is located. The remote monitor/controller **20** could be disposed in a different room of the same building in which the pump **12** is disposed, or in a different building than the one in which the pump **12** is disposed. The remote monitor/controller **20** is connected to a conventional voice/data modem **22** via a data link **24**, and the modem **22** is also connected to a telephone **26** via a voice link **28**. The infusion pump **12** is connected to a conventional voice/data modem **30** via a data link **32**, and the modem **30** is connected to a telephone **34** via a voice link **36**. The two modems **22**, **30** are interconnected to bidirectional voice and data communication via a communication link **38**, which could be a telephone line, for example.

FIG. 2 is a block diagram of the electronics of the remote monitor/controller **20** shown schematically in FIG. 1. Referring to FIG. 2, the remote monitor/controller **20** includes a microprocessor (MP) **60**, a read-only memory (ROM) **62**, a random-access memory (RAM) **64**, and an input/output (I/O) circuit **66**, all of which are interconnected by an address/data bus **68**. The microprocessor **60** has a transmit buffer (XMIT) **70** for transmitting data bytes and a receive buffer (REC) **72** for receiving data bytes. The remote monitor/controller **20** has a keyboard **74** connected to the I/O circuit **66** via a line **76**, a display device **78**, such as a CRT, connected to the I/O circuit **66** via a line **80**, and an input device, such as an electronic mouse **82**, connected to the I/O circuit **66** via a line **84**. The remote monitor/controller **20** can also include one or more disk drives, such as a hard disk drive or a floppy disk drive.

FIG. 3 is a front view of one embodiment of the infusion pump **12** shown schematically in FIG. 1. Referring to FIG. 3, the pump **12** has an input device in the form of a keypad **90** via which a user may input data and commands and a display **92** for displaying textual messages to the user.

A block diagram of the electronics of the infusion pump **12** is shown in FIG. 4. Referring to FIG. 4, the pump **12** includes a controller **100**, an electrically programmable read-only memory (EPROM) **102** having a built-in I/O interface **102***a*, a nonvolatile RAM **104**, a real-time clock **106** and the display **92**, all of which are interconnected by a communications bus **108**. The display **92** has a backlight **110** which is selectively activated by an enable signal generated on a line **112** interconnecting the controller **100** and the backlight **110**. Both the RAM **104** and the real-time clock **106** are connected to a battery **114** which supplies power to them only in the absence of system power. The controller **100** has a transmit buffer **116** and a receive buffer **118** connected to the communications bus **108**.

The controller **100** controls the medicant infusion rate by periodically transmitting a control signal to an amplifier circuit **120** via a line **122** to drive a pump motor **124** which drives a pumping mechanism **126**, such as a rotary pump wheel (not shown) adapted to make contact with a portion of the liquid conduit **16** (FIG. 1) connected to the catheter **14**.

The controller **100** receives periodic inputs from a shaft encoder (SE) sensor **130**, which is disposed on the shaft of the motor **124**. The SE sensor **130** may be a two-phase motion sensing encoder which provides two signal outputs to the controller **100**. The rotational speed of the motor **124** and its direction of rotation are determined by the controller **100** based upon the rate and phase relationship between the two signal outputs.

The SE encoder **130** periodically transmits the signals to the controller **100** via a line **132**. Each time the signals are transmitted, an interrupt is generated, and the controller **100** compares the actual position of the motor shaft with its desired position, and transmits a new control signal, such as a pulse-width modulated signal, to the amplifier **120** via the line **122** to ensure that the actual speed of the motor **124** corresponds to the motor speed required for the desired medicant infusion rate. The interrupts caused by the SE sensor **130** are assigned to the highest priority so that they are responded to immediately, before any other actions are taken by the controller **100**.

The pump **12** has a number of other features not described herein, which are disclosed in the following patent applications, each of which is incorporated herein by reference: U.S. Ser. No. 08/399,184, filed Mar. 6, 1995, entitled "Infusion Pump Having Power Saving Modes"; U.S. Ser. No. 08/398,977, filed Mar. 6, 1995, entitled "Infusion Pump With Selective Backlight"; U.S. Ser. No. 08/398,980, filed Mar. 6, 1995, entitled "Infusion Pump With Different Operating Modes"; U.S. Ser. No. 08/398,886, filed Mar. 6, 1995, entitled "Cassette For An Infusion Pump; U.S. Ser. No. 08/399,183, filed Mar. 6, 1995, entitled "Infusion Pump With Dual-Latching Mechanism"; U.S. Ser. No. 08/398,887, filed Mar. 6, 1995, entitled "Infusion Pump With Historical Data Recording."

The operation of the infusion pump **12** is controlled by a computer program stored in the EPROM **104** and executed by the controller **100**. A flowchart **200** of the overall operation is illustrated in FIG. 5. Referring to FIG. 5, when the pump **12** is turned on, at step **202** the pump is initialized and a test of the pump operation is performed. The pump **12** may be turned off temporarily during an infusion, in which case the pump **12** may continue the infusion when it is turned back on, as described below. At step **204**, if there is any remaining volume of liquid to be infused by the pump or any additional time remaining for an infusion, which would be the case where the pump was temporarily turned off during an infusion, the program branches to step **206**, where the user is asked, via a message displayed on the display **92**, whether the previous infusion should be resumed. If the user answers yes (via the keypad **90**), the program branches to a

ready-to-run step **210**. If the previous infusion is not to be resumed, the program branches to step **212**.

The infusion pump **12** has a lockout mode in which the user may be prevented from programming the infusion parameters, such as the volume to be infused or the rate of infusion. For example, the pump **12** could be programmed by a medical assistant to deliver a particular infusion having a particular flow profile, flow rate and volume to be infused. After programming that infusion, the medical assistant could place the pump in lockout mode, which would prevent the patient from changing any of the infusion parameters. At step **212**, if the pump **12** has been previously placed in lockout mode, the program branches directly to the ready-to-run step **210**, bypassing all programming steps.

At step **212**, if the pump is not in lockout mode, the program branches to step **214**, at which point the program prompts the user, via the display **92**, to input whether the patient should be allowed to program the pump during the subsequent infusion. If the pump is not to be programmable, the program branches to step **216** where a lockout sequence is performed by requesting the user to input which infusion modes should be locked out. If the pump is to be programmable by the patient, the program bypasses step **216**.

The infusion pump **12** has five basic modes of infusion: 1) a continuous mode in which the pump delivers a single volume at a single rate; 2) an auto-ramp mode in which the pump delivers liquid at a rate that gradually increases to a threshold rate, stays constant at the threshold rate, and then gradually decreases; 3) an intermittent mode in which the pump delivers discrete liquid volumes spaced over relatively long periods of time, such as a liquid volume every three hours; 4) a custom mode in which the pump can be programmed to deliver a unique infusion rate during each of 25 different time periods; and 5) a pain-controlled analgesic (PCA) mode during which the pump will periodically infuse boluses of analgesic in response to periodic requests by the patient.

At step **218**, the pump **12** generates on the display **92** the prompt "Continuous?" to the user. If the user desires to use the pump in its continuous mode, the user answers "yes" via the keypad **90**, and the program branches to step **220** at which the continuous mode is programmed by the user by entering a number of infusion parameters, such as the desired infusion rate, the volume to be infused, etc. At step **218**, if the user does not want to use the continuous mode, the user answers "No," and the program branches to step **222**. Steps **222–236** are generally the same as steps **218** and **220**, except that the user may be prompted for different infusion parameters, depending on which of the five possible infusion modes is selected.

After the completion of one of the steps **220**, **224**, **228**, **232**, or **236**, the program branches to the ready-to-run step **210**. When the user presses the "Run" key, the pump **12** enters the run mode **260** and infuses the patient with a liquid medicant in accordance with the infusion mode selected at one of steps **218**, **222**, **226**, **230**, **234** and the infusion parameters entered at one of steps **220**, **224**, **228**, **232**, **236**. The pump **12** remains in the run mode **260** until the "Hold" key is pressed, as determined at step **262**. Upon the occurrence of an alarm condition, an alarm is reported at step **264**. At step **262**, if the hold key is pressed, the infusion is stopped at step **266**, and the pump **12** waits for the run key to be pressed at step **268** or the on/off switch to be turned off at step **270**.

Summarizing the operation described above, if the pump is to be utilized in lockout mode, a medical assistant turns the pump on, programs the desired infusion mode at one of steps **220**, **224**, **228**, **232**, **236**, and then turns the pump off. The programmed infusion parameters will be retained in the memory **104**. The medical assistant would then turn the pump back on, press the "No" key in response to the "Programmable?" prompt at step **214**, enter the lockout information at step **216**, and then turn the pump off again. When the patient subsequently turned on the pump to perform the infusion, the program would proceed from step **212** directly to the ready-to-run step **210**, which would prevent the patient from altering the infusion parameters.

If the lockout mode was not utilized, the medical assistant or the patient could turn the pump on, program the desired infusion mode, and then press the "Run" key to start the infusion without ever turning the pump off.

During programming and operation, the infusion pump **12** automatically records in the non-volatile memory **104** all significant infusion data to generate a complete historical data record which can be later retrieved from the memory **104** and used for various purposes, including clinical purposes to aid in determining how effective a particular infusion therapy was and treatment purposes to confirm that the prescribed infusion was actually delivered.

FIG. **6** illustrates various steps at which infusion data is recorded that are performed during the overall pump operation shown generally in FIG. **5**. The infusion data recorded in the memory **104** is set forth in Table 1 below. A number of events which trigger the storage of data are listed in the left-hand column of Table 1, and the infusion data that is recorded upon the occurrence of each event is listed in the right-hand column of Table 1. The time at which the infusion data is recorded, which is determined by the real-time clock **106**, is also stored along with the infusion data.

TABLE 1

EVENT	DATA RECORDED
Power On	Date and Time
Program	Infusion parameters. See Table 2.
Run	Infusion parameters. See Table 2.
Hold	Total Volume Infused
Restart	Time of Restart
Rate Changes	Total Volume Infused, Rate, Volume
Alarms	Total Volume Infused, Alarm Type
Infusion Complete	Total Volume Infused
Malfunctions	Total Volume Infused, Malfunction Type
Resume	Infusion parameters. See Table 2.
Maintenance Date	Date
Patient ID	Patient ID Number
Serial No.	Serial Number
Language Change	New Language
Lockout	Modes Locked Out
Pressure Select	New Pressure Setting
Bolus Request	Given/Not Given, Bolus Amount
Titration	New Parameters
Power Off	Time of Power Off
Version No.	Software Version Number

Referring to Table 1 and FIG. **6**, when the power to the infusion pump **12** is turned on, the date and time of the power turn-on is recorded. When the pump is completely programmed pursuant to one of steps **220**, **224**, **228**, **232**, **236** (FIG. **5**) as determined at step **302**, the programmed infusion parameters are stored at step **304**, along with the time of such storage. The particular parameters that are stored depend upon which infusion mode was programmed. Several examples of infusion parameters that are stored for each of a number of infusion modes are illustrated in Table 2 set forth below.

TABLE 2

INFUSION MODE	INFUSION PARAMETERS
Continuous	Infusion Mode
	Infusion Rate
	Volume To Be Infused
	Delay Time
	Total Bag Volume
	KVO Rate
Auto-Ramp	Infusion Mode
	Infusion Rate
	Volume To Be Infused
	Delay Time
	Total Bag Volume
	Duration of Up-Ramp
	Duration of Down-Ramp
	KVO Rate
Intermittent	Infusion Mode
	Total Infusion Time
	Number of Doses
	Dose Time
	Dose Volume
	KVO Rate

When the pump enters the run mode **260** (FIG. **5**) as determined at step **306**, the time at which the run mode was begun, along with the parameters pursuant to which the infusion is performed, are stored at step **308**.

At step **310**, if the hold key is pressed, then the time at which the hold key was pressed along with the total volume infused at the time the hold key was pressed are stored at step **312**. The pump also stores any infusion rate changes, such as changes caused by switching from a continuous rate to a keep-vein-open (KVO) rate, or in the intermittent mode, changing from a KVO rate to a higher infusion rate, the presence of which are detected at step **314**. The new rate and the time at which the new rate started are stored at step **316**.

At step **318**, if any alarms are generated, the alarm type, the time at which the alarm occurred, and the total volume infused at the time of the alarm are recorded at step **320**. If the infusion is completed as determined at step **322**, the program branches to step **324** where the time at which the infusion was completed is stored along with the total volume infused. At step **326**, if there is a malfunction, the malfunction type, the time at which the malfunction occurred, and the total volume infused at the time of the malfunction are recorded at step **328**.

At step **330**, if the infusion is resumed (when the pump is turned back on after having been turned off during an infusion), the time at which the infusion is resumed along with the infusion parameters are stored at step **332**. Upon the completion of the programming of a lockout sequence as determined at step **334** (i.e. after step **216** of FIG. **5**), the time at which the programming of the lockout was completed is stored along with the infusion modes that were locked out. At step **338**, upon the detection of a bolus request, the time at which the bolus was requested is stored at step **340**, along with an indication whether the bolus was actually given and the amount of the bolus.

FIG. **7** illustrates the data organization of a portion of the RAM **104** in which infusion data (the data stored during the steps of FIG. **6**) is stored. Referring to FIG. **7**, the infusion data is stored in a number of memory locations **372**. Data may be written to the memory locations **372** utilizing a pointer **376** which specifies the memory location at which data should be next stored.

FIG. **8** is a flowchart of a routine **380** for storing data in the memory locations **372**. Referring to FIG. **8**, at step **382** the pointer **376** is set to the address of the next memory location **372** in which data is to be stored. At step **384**, if the pointer **376** is at the last memory location in which data may be stored, the routine branches to step **386** where the pointer is set to the address of the first memory location in which data may be stored. As a consequence of steps **384**, **386**, the contents of the memory locations **372** are periodically overwritten with new data; however, the number of memory locations **372** is sufficiently large so that several months of data, for example, is stored before being overwritten. At steps **388** and **390** the data is stored in the memory location **372** specified by the pointer **376** (the data includes a time stamp generated from the real-time clock **106** and event data specifying the particular infusion event).

FIGS. **9**, **10**, and **12** are flowcharts of various routines that are performed by the remote monitor/controller **20**. As described in more detail below, the remote monitor/controller **20** may be used to monitor the operation of the infusion pump **12**, to control the operation of the infusion pump **12**, and/or to transfer infusion data and patient data from the infusion pump **12** so that such data can be reviewed by a health care professional at a location remote from the patient.

The remote monitor/controller **20** is designed to interface with different types of infusion pumps. In order to determine which type of infusion pump the remote monitor/controller **20** is operatively coupled, a pump identification routine **400** performed after the communication link between the remote monitor/controller **20** and the infusion pump **12** is established. Referring to FIG. **9**, at step **402** the remote monitor/controller **20** transmits a pump identification (ID) request to the infusion pump **12** via the communication link **38**. In response to the pump ID request, the pump **12** transmits a multi-character ID code back to the remote monitor/controller **20**. The ID code may include, for example, one or more characters identifying the pump model and/or one or more characters identifying the software version of the pump. At step **404**, the remote monitor/controller **20** reads the characters sent from the pump **12** until all characters are received as determined at step **406** or until a predetermined time period, e.g. five seconds, elapses. The time period may be determined by a timer (not shown). The remote monitor/controller **20** may determine that all characters have been received by, for example, identifying one or more termination characters, such as a carriage-return character <CR> followed by a line-feed character <LF>.

Step **408** determines whether a correct response was received from the pump **12**, which may be determined checking the characters received from the pump **12** against a list of possible ID codes. If a correct response was received, the routine branches to step **410** where the pump type is determined, for example, by comparing the received pump ID code with at least one possible ID code which identifies a particular type of infusion pump, or by comparing the received pump ID code with a number of possible ID codes, each of which identifies a particular type of infusion pump. As used herein, the "type" of infusion pump may relate to the model of the pump or the software version of the pump.

If a correct response was not received as determined by step **408**, at step **412** the routine determines whether the predetermined time period measured by the timer has expired prior to receiving a termination character. If so, the routine branches to step **414** where an error message is generated due to the pump's failure to respond to the pump ID request.

At step **412**, if some type of response (not a correct response) was received before the timer expired, the routine branches to step **416**. Steps **416**–**426** comprise a second way

of determining the type of infusion pump **12** connected to the remote monitor/controller **20**, which is based on the number of characters in the display **92** of the pump **12**. For example, a first type of infusion pump may have a display capable of displaying 12 characters, whereas a second type of infusion pump may have a display capable of displaying 32 characters. Steps **416–426** determine the type of infusion pump based on the number of characters in the display.

At step **416**, the remote monitor/controller **20** transmits a pump display request to the infusion pump **12** to request the pump **12** to transmit the content of its display **92**. At step **418**, the remote monitor/controller **20** reads the display characters transmitted from the pump **12**. At step **420**, if a predetermined period of time has elapsed or if a terminating character is received, the routine branches to step **422**. At step **422**, if the predetermined time period measured by the timer elapsed prior to the receipt of a terminating character, the routine branches to step **424** where an appropriate error message is generated. At step **426**, the type of pump is determined based on the number of display characters that were received.

The routine could also exit step **420** if a predetermined number of characters are received. In that case, where the remote monitor/controller **20** was designed to interface with two different types of infusion pumps, one having a display capability of 12 characters and another having a display capability of 32 characters, if the remote monitor/controller **20** received more than 12 display characters at step **420**, it would immediately be able to determine that the pump type corresponded to a pump with a 32-character display capability.

The remote monitor/controller **20** allows four basic functions to be performed, including controlling the infusion pump **12**, monitoring the operation of the pump **12**, transferring infusion data from the pump **12** to the remote monitor/controller **20**, and viewing the data. The user may perform one of those functions by selecting an operational mode displayed on the display device **78** (FIG. **2**) of the remote monitor/controller **20** via the mouse **82**. These modes include a command mode in which a health care professional at the remote monitor/controller **20** may transmit command signals to the infusion pump **12** to control its operation, a monitoring mode in which the infusion pump **12** will continually transmit the contents of its visual display **92** to the remote monitor/controller **20**, a download data mode in which infusion data is transferred from the pump **12** to the remote monitor/controller **20**, and a view data mode in which the infusion data may be viewed on the display **78** of the remote monitor/controller **20**.

FIG. **10** illustrates a flowchart **450** of the basic operation of the remote monitor/controller **20**. Referring to FIG. **10**, at step **452**, if the user selected the command mode described above, the routine branches to step **454** where a display of the keypad **90** of the infusion pump **12** is shown on the display device **78**. The display shown at step **454** comprises a plurality of virtual entry keys having a spatial configuration substantially the same as the entry keys of the keypad **90** of the particular infusion pump type which is connected to the remote monitor/controller **20**. An example of such a visual display is shown in FIG. **11A**.

It should be noted that the virtual keypad shown in FIG. **11A** is the same as the actual keypad **90** of the pump **12**, which is shown in FIG. **3** (except that the on/off key of the pump **12** is replaced with a reset key in the virtual key display). Where a different type of pump having a different keypad is attached to the remote monitor/controller **20**, that particular keypad is displayed on the display device **78**. An example of a different virtual keypad is shown in FIG. **11B**. Various virtual keypad configurations may be stored in the memory of the remote monitor/controller **20**, each virtual keypad configuration having a pump type code associated therewith. Since the remote monitor/controller **20** initially determined the type of pump to which it was attached (via the routine of FIG. **9**), it can retrieve from memory and display the corresponding virtual keypad for that type of pump.

After the virtual keypad is displayed, the health care professional may control the operation of the infusion pump **12** by selecting any of the virtual keys with the mouse **82**. Other ways of selecting the keys could be utilized, such as a touch-sensitive screen or a display screen activated by radiation sensors. The infusion pump **12** responds to commands entered via its keypad **90** and to commands generated from the remote monitor/controller **20**. At steps **456** and **458**, any commands entered by the health care professional are transmitted to the infusion pump **12**, and at steps **460** and **462**, the display of the pump **12** is transferred to the remote monitor/controller **20** and displayed on the display device **78** of the remote monitor/controller **20**. At step **464**, if the user exits the command mode, the routine branches back to step **452**.

At step **465**, if the health care professional selected the monitor mode, the routine branches to step **466** where a visual display of the pump display **92** is shown on the display device **78**. At step **467**, the contents of the pump display **92** are transferred to the remote monitor/controller **20**, and at step **468** those contents are displayed in the visual display generated at step **466**. At step **469**, if the user exits the monitor mode, the routine branches back to step **452**; otherwise, the routine branches back to step **467** so that the contents of the pump display **92** are continuously shown on the display device **78** at step **468** (the display **92** of the infusion pump **12** changes in accordance with the pump operation so that the pump operation can be monitored by viewing the display **92**). Step **467** may be accomplished, for example, by transmitting a pump display request to the pump **12** (via steps similar to steps **416–420** described above).

If the health care professional inputs a request to download data from the pump **12** to the remote monitor/controller **20** as determined at step **470**, the routine branches to step **472** where the data transfer is accomplished, as described below in connection with FIGS. **13–14**. If the user inputs a view data log request as determined at step **474**, the routine branches to step **476** where data previously downloaded at step **472** can be viewed on the display device **78** of the remote monitor/controller **20**. The user may exit the mode select routine **450** via step **478**.

FIG. **12** illustrates one routine that could be used to implement the transmit command step **458** shown schematically in FIG. **10**. Referring to FIG. **12**, the pump command is transmitted from the remote monitor/controller **20** at step **480**, and then the infusion pump **12** transmits to the remote monitor/controller **20** an echo of the command so that the remote monitor/controller **20** knows that command was received properly by the pump **21**. The characters making up the echo are received at steps **482–484**, and if the echo is not correct, an error message is displayed to the health care professional. At step **490**, the remote monitor/controller **20** sends an acknowledgement of the echo to the pump **12**.

The transfer of data from the infusion pump **12** to the remote monitor/controller **20** shown schematically in step **468** of FIG. **10** is accomplished via a receive interrupt service routine **500** and a transmit interrupt service routine

550 that are performed by the infusion pump 12. Flowcharts of the routines 500, 550 are shown in FIGS. 13 and 14.

The receive routine 500 shown in FIG. 13 is invoked upon the generation of a receive interrupt by the pump controller 100. The receive interrupt indicates that a message has been received in the receive buffer 118 of the controller 100 from the remote monitor/controller 20. When a download data command is sent to the infusion pump 12 (as determined at step 466 of FIG. 10), a data dump flag is set to logic "1," indicating that a data transfer or dump from the pump 12 to the remote monitor/controller 20 is in progress. The data transfer is performed in a segmented fashion. Instead of sending all of the infusion data and patient data stored in the RAM 104 to the remote monitor/controller 20 in a single, continuous stream, the data is sent in segmented portions, each of which is separated in time from its adjacent portions by a period of time, e.g. 100 microseconds.

Referring to FIG. 13, when the routine begins at step 502, a character or message will have been just received in the receive buffer 118. At step 502, if the data dump flag is active, meaning that a data transfer is already in progress, then the routine branches to step 504, where the data dump flag is set to logic "0," effectively terminating the data dump operation, and an error message is transmitted to the remote monitor/controller 20 at step 506. This is done to prevent the data dump operation from interfering with any commands that are transmitted from the remote monitor/controller 20 to the infusion pump 12.

If the data dump flag was not active as determined at step 502, the routine branches to step 508 where the message just received in the receive buffer 118 is checked to determine whether it is a data dump command. If it is not, then the routine branches to step 510 where the pump 12 responds to the command.

If the message is a data dump command, the routine branches to step 512 where a transmit pointer 513 (see FIG. 7) is set to the oldest data in the RAM 104 that has not yet been transmitted to the remote monitor/controller 20. At step 514, the data dump flag is set to logic "1" since a new data transfer operation is beginning. At step 516, the data byte specified by the transmit pointer 513 is retrieved from the RAM 104, and at step 518 the position of the transmit pointer 513 is updated (e.g. incremented) to point to the address of the next data byte to be transmitted. At step 520, the data byte retrieved at step 516 is formatted in ASCII; at step 522 the transmit interrupt is enabled; and at step 524 the reformatted data byte is transmitted from the infusion pump transmit buffer 116 to the remote monitor/controller 20 over the data link 38.

When the first data byte is sent out from the transmit buffer 116, a transmit interrupt is generated by the controller 100 to indicate that the transmit buffer 116 is empty and that another data byte can be transmitted. Upon the generation of the transmit interrupt, the transmit routine 550 is performed. Referring to FIG. 14, at step 552 the status of the data dump flag is checked. If the flag is not active, meaning that a data dump operation is not in progress, the routine branches to step 554 where the routine responds to the other interrupt. If the data dump flag is active, then the routine branches to step 556, where it determines whether all of the segmented portions of the infusion data have been transmitted. This may be accomplished, for example, by determining if the transmit pointer 513 and the pointer 376 (FIG. 7) are pointing to the same memory location. If all the requested data has been sent, the routine branches to step 558, where the transmit interrupt is disabled, and then to step 560 where the data dump flag is reset to logic "0," effectively ending the data transfer operation.

If not all the data has been transferred as determined at step 556, the routine branches to step 562 where the data byte specified by the transmit pointer 513 is retrieved from the RAM 104. At step 564 the position of the transmit pointer is updated to point to the address of the next data byte to be transmitted. At step 566, the data byte retrieved at step 562 is formatted in ASCII, and at step 568 the reformatted data byte is transmitted from the infusion pump transmit buffer 116 to the remote monitor/controller 20 over the data link 38.

The transmit interrupts generated by the controller 100 to transfer the segmented data portions to the remote monitor/controller 20 are assigned a lower priority than the interrupts generated in response to input of the shaft encoder sensor 130, which is necessary to provide the desired infusion rate. Consequently, the transfer of the infusion data and patient data does not interfere with the ability of the pump 12 to provide the desired infusion rate, and the data transfer can occur while the pump is infusing the patient with the medicant.

FIG. 15 is an illustration of a graphical user menu that may be shown on the display device 78 of the remote monitor/controller 20. The health care professional may select particular data for transfer or viewing, via a number of different parameters such as beginning date, ending date, types of data, etc. The particular manner in which particular data may be selected for transfer or viewing is not considered important to the invention.

Modifications and alternative embodiments of the invention will be apparent to those skilled in the art in view of the foregoing description. This description is to be construed as illustrative only, and is for the purpose of teaching those skilled in the art the best mode of carrying out the invention. The details of the structure and method may be varied substantially without departing from the spirit of the invention, and the exclusive use of all modifications which come within the scope of the appended claims is reserved.

What is claimed is:

1. A medical apparatus, comprising:

an infusion pump for administering a liquid medicant to a patient, said infusion pump being disposed at a first room location and comprising:

a liquid injection device adapted to be connected to the patient;

a conduit connected to said liquid injection device;

a pumping mechanism for pumping said liquid medicant through said conduit and into said patient via said liquid injection device and for generating a pump signal indicative of the pump speed and for generating a pump interrupt when said pump signal is generated;

a controller for controlling said pumping mechanism; and

memory means for storing data regarding said liquid medicant administered to said patient;

a remote monitor for monitoring said liquid medicant administered to said patient, said remote monitor being disposed at a second room location remote from said first room location; and

means for transferring said data from said infusion pump to said remote monitor effective for transferring said data real-time while said infusion pump is administering said liquid medicant to said patient and for generating a transfer interrupt when said data is to be transferred;

wherein said controller responds to said interrupts in accordance with predetermined priorities and wherein said pump priority is assigned the highest priority.

2. An apparatus as defined in claim 1 wherein said means for transferring said data from said infusion pump to said remote monitor comprises means for transmitting said data in segmented, noncontinuous data portions.

3. An apparatus as defined in claim 1 wherein said means for transferring said data from said infusion pump to said remote monitor comprises:

means for repeatedly transmitting portions of said data from said infusion pump to said remote monitor; and

means for generating an interrupt when one of said data portions has been transmitted to said remote monitor, said interrupt causing said transmitting means to transmit another of said data portions from said infusion pump to said remote monitor.

4. An apparatus as defined in claim 1 wherein said means for transferring said data from said infusion pump to said remote monitor comprises:

means for loading a portion of said data into a transmit buffer coupled to said remote monitor via a communication link;

means for generating an interrupt when said data portion has been transmitted from said transmit buffer to said remote monitor via said communication link, said interrupt causing said loading means to transmit another of said data portions from said infusion pump to said remote monitor.

5. A medical apparatus, comprising:

a medical device for administering a medical treatment to a patient, said medical device being disposed at a first room location and comprising:

means for administering said medical treatment to said patient and for generating a signal indicative of the rate of administering of said medical treatment and for generating an administrating interrupt when said administrating signal is generated;

memory means for storing data regarding said medical treatment administered to said patient; and

a controller for controlling said administering means;

a remote monitor for monitoring said medical treatment administered to said patient, said remote monitor being disposed at a second room location remote from said first room location; and

means for transferring said data from said medical device to said remote monitor effective for transferring said data real-time while said medical device is administering said medical treatment to said patient and for generating a transfer interrupt when said data is to be transferred;

wherein said controller responds to said interrupts in accordance with predetermined priorities and wherein said administering priority is assigned the highest priority.

6. An apparatus as defined in claim 5 wherein said means for transferring said data from said medical device to said remote monitor comprises means for transmitting said data in segmented, noncontinuous data portions.

7. An apparatus as defined in claim 5 wherein said means for transferring said data from said medical device to said remote monitor comprises:

means for repeatedly transmitting portions of said data from said medical device to said remote monitor; and

means for generating an interrupt when one of said data portions has been transmitted to said remote monitor, said interrupt causing said transmitting means to transmit another of said data portions from said medical device to said remote monitor.

8. An apparatus as defined in claim 5 wherein said means for transferring said data from said medical device to said remote monitor comprises:

means for loading a portion of said data into a transmit buffer coupled to said remote monitor via a communication link;

means for generating an interrupt when said data portion has been transmitted from said transmit buffer to said remote monitor via said communication link, said interrupt causing said loading means to transmit another of said data portions from said medical device to said remote monitor.

9. An apparatus as defined in claim 5 wherein said medical device comprises an infusion pump and wherein said means for administering said medical treatment to said patient comprises:

a liquid injection device adapted to be connected to the patient;

a conduit connected to said liquid injection device; and

a pumping mechanism for pumping a liquid drug through said conduit and into said patient via said liquid injection devices.

10. A medical apparatus, comprising:

a medical device for administering a medical treatment to a patient, said medical device being disposed at a first room location and comprising:

means for administering said medical treatment to said patient and for generating a signal indicative of the rate of administering said medical treatment and for generating an administering interrupt when said administering signal is generated;

memory means for storing data regarding said medical treatment administered to said patient; and

a controller for controlling said administering means;

a remote monitor for monitoring said medical treatment administered to said patient, said remote monitor being disposed at a second room location remote from said first room location;

a communication link operatively coupled between said medical device and said remote monitor;

means for transferring said data from said medical device to said remote monitor via said communication link; and

means for allowing voice communication between said medical device and said remote monitor via said communication link effective for allowing said voice communication real-time while said data is being transferred from said medical device to said remote monitor and for generating a voice interrupt when said voice communication is initiated;

wherein said controller responds to said interrupts in accordance with predetermined priorities and wherein said administering priority is assigned the highest priority.

11. An apparatus as defined in claim 10 wherein said means for allowing voice communication comprises:

a first voice/data modem operatively coupled to said medical device; and

a second voice/data modem operatively coupled to said remote monitor, said first and second voice/data modems being coupled to said communication link.

12. An apparatus as defined in claim 10 wherein said communication link comprises a telephone line.

13. An apparatus as defined in claim 10 wherein said medical device comprises a programmable infusion pump.

14. An apparatus as defined in claim 10 additionally comprising means for controlling said medical treatment being administered to the patient from said second room location.

15. A medical apparatus, comprising:

a medical device for administering a medical treatment to a patient, said medical device being disposed at a first room location and comprising:

means for administering said medical treatment to said patient;

an input device operatively coupled to said administering means for allowing a user to input control commands to control said administering means, said input device having a plurality of entry keys disposed in a spatial configuration; and

memory means for storing data regarding said medical treatment administered to said patient;

a remote monitor for monitoring and controlling said medical treatment administered to said patient, said remote monitor being disposed at a second room location remote from said first room location, said remote controller comprising:

a display device;

means operatively coupled to said display device for generating a visual display of a plurality of virtual entry keys, said virtual entry keys having a spatial configuration substantially the same as said entry keys of said input device of said programmable medical device; and

means for allowing a user at said second room location to activate said virtual keys to allow the user to control the operation of said programmable medical device from said second room location; and

means for transferring said data from said medical device to said remote monitor while said medical device is administering said medical treatment to said patient.

16. An apparatus as defined in claim 15 wherein said means for transferring said data from said medical device to said remote monitor comprises means for transmitting said data in segmented, noncontinuous data portions.

17. An apparatus as defined in claim 15 wherein said means for transferring said data from said medical device to said remote monitor comprises:

means for repeatedly transmitting portions of said data from said medical device to said remote monitor; and

means for generating an interrupt when one of said data portions has been transmitted to said remote monitor, said interrupt causing said transmitting means to transmit another of said data portions from said medical device to said remote monitor.

18. An apparatus as defined in claim 15 wherein said means for transferring said data from said medical device to said remote monitor comprises:

means for loading a portion of said data into a transmit buffer coupled to said remote monitor via a communication link;

means for generating an interrupt when said data portion has been transmitted from said transmit buffer to said remote monitor via said communication link, said interrupt causing said loading means to transmit another of said data portions from said medical device to said remote monitor.

19. An apparatus as defined in claim 15 wherein said medical device comprises an infusion pump and wherein said means for administering said medical treatment to said patient comprises:

a liquid injection device adapted to be connected to the patient;

a conduit connected to said liquid injection device;

a pumping mechanism for pumping a liquid drug through said conduit and into said patient via said liquid injection device; and

a controller for controlling said pumping mechanism.

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